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FISCAL YEAR 1986 DEPARTMENT OF ENERGY AUTHORIZATION

(Fossil Energy)

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

MARCH 6, 1985

[No. 24]

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*Ranking Republican Member.
**Serving on Committee on the Budget for 99th Congress.

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1986 DEPARTMENT OF ENERGY AUTHORIZATION

WEDNESDAY, MARCH 6, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Staff present: William T. Harvey, staff director; and Bill Gordon, minority technical consultant.

Mr. Fuqua. The subcommittee will be in order. Today's hearing is devoted to the U.S. Department of Energy's fiscal year 1986 budget request for fossil energy. As you all know, we had intended to hold a series of such hearings but a recently imposed House schedule made that impossible. The cooperation of all our participants, both witnesses and those people providing material for the record, is greatly appreciated. From all these valuable contributions we hope to explore the rationale for the large cuts in the fiscal year 1986 budget request. The administration proposes a fossil energy program of $243 million, a reduction of 30-percent below the fiscal year 1985 appropriations of $347 million.

Some activities suffer far more than others. The MHD Program would be totally eliminated, although $31 million was appropriated last year. A 77-percent reduction in the Fuel Cell Program drops it to $9.3 million from $40.8 million in fiscal year 1985. Surface coal gasification, at the proposed $15 million level, is less than half the amount provided in fiscal year 1985.

These and other reductions raise the concern that we may not be using our time intelligently. We are all thankful for present energy abundance. It is a welcome relief from gas lines and rising fuel prices. But there is nothing to indicate the continuation of such conditions indefinitely. It does, however, give us an excellent opportunity to prepare for any detrimental change by addressing problems before they arise. Now is the time to learn how to use coal—our most plentiful energy resource—in more efficient and environmentally acceptable methods. We must continue basic and applied research programs on conversion and utilization processes, supporting those promising technologies to the point of industry acceptance and commercialization. It is not readily apparent that DOE's fiscal year 1986 budget request adequately fulfills that requirement.

Again, the cooperation of our witnesses is appreciated. We look forward to your testimony.

Before we present our witnesses, Mr. Sensenbrenner, do you have any——

Mr. **Sensenbrenner**. Thank you, Mr. Chairman, for the opportunity to extend a welcome to Mr. Vaughan, the Assistant Secretary for Fossil Energy at DOE.

Thus far into the subcommittee's authorization hearings on the Department of Energy's R&D programs, I have been quite satisfied with the funding requests of the Department. We all recognize the need to slow the growth of Federal spending. For the DOE programs considered to date, the Department should be commended for demonstrating its willingness to conduct its programs within these limitations.

I must admit, though, that I am concerned over the budget request before us today. I'm afraid that the magnitude of the proposed cuts in the fossil energy R&D program could seriously disrupt, and perhaps setback, progress we have made in several fossil fuel technologies. It will be years before renewable energy resources make a significant contribution to our energy supply. In the interim, this committee has placed a premium on increasing utilization of our abundant coal resources by improving the environmental, technical, and economic performance of coal and increasing its application and flexibility of coal-based systems.

In today's hearing, I'm sure the testimony presented will help members determine if it is wise and appropriate to selectively slash many of these efforts at this stage of their development. I have to extend my apologies to the witnesses today because I have another hearing of another subcommittee, of which I am the ranking minority member, starting in about 15 minutes. I am glad you have all put in written testimony which I will read and review, perhaps during that other subcommittee hearing.

I would ask your indulgence in being excused, and thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Sensenbrenner. Our first witness is Mr. William A. Vaughan, the Assistant Secretary for Fossil Energy. Mr. McCurdy, do you have a——

Mr. **McCurdy**. Mr. Chairman, I do have a statement but I can enter it into the record.

[The prepared opening statement of Mr. McCurdy follows:]

Opening Statement of Hon. Dave McCurdy

My interest in the Fossil Energy budget lies primarily with petroleum research; more specifically, enhanced oil recovery research. Oil experts in my state tell me that oil production in the lower 48 states has declined 25 percent in recent years. Most of the decline has been in key producing states, including ones represented by members of this panel. New Mexico, Texas, Oklahoma and Illinois are a few. In addition, employment in petroleum extraction dropped 13 percent in 1983. I am afraid that if this trend continues, many producing states will be out of the oil business.

How do we offset a decline that robs our state treasuries of revenue, our citizens of their jobs, and the American public of its needed energy supply? We go after oil that has been abandoned in known U.S. reservoirs. By some estimates there is 300 billion barrels yet to be extracted from wells. Only enhanced oil recovery methods can reach this oil. The federal government has a clear role in developing the technology to accomplish this.

Are the oil companies investing in EOR research? Yes, but they are not producing data for general use. Their information is too site-specific.

Are the oil companies producing oil from abandoned wells through EOR methods? Yes, but not fast enough and only in a few isolated areas with favorable conditions. It's cheaper to get energy other ways. They can purchase or merge to gain new reserves. They can drill offshore or explore abroad. Unfortunately, our states don't have the same mobility.

The best means of developing the technology to boost our reserves and secure our energy independence lie with federal EOR efforts. The sooner this research yields the models and data base needed, the sooner we can offset declining production and upright our damaged producing states economies.

The public sector is greatly served by the kind of basic, long-range EOR research done at the National Institute of Petroleum and Energy Research and our country's universities.

Dr. Charles Mankin of the Oklahoma Geological Survey was to testify on the benefits of EOR, but could not accommodate the hearing date change to his schedule. I would refer members to his testimony for further information.

I hope we will support EOR research at an adequate level and I look forward to Assistant Secretary Vaughan's assessment of DOE's progress in this area. Thank you.

Mr. McCurdy. I have some questions, also, that—I too have another subcommittee at 10 that is organizing, and I have some written questions—but if we don't get to the point that I can ask them directly, I'd like to have them entered.

Mr. Fuqua. We will certainly oblige. Thank you for being here, Mr. Vaughan. You may proceed any way you choose.

STATEMENT OF HON. WILLIAM A. VAUGHAN, ASSISTANT SECRETARY FOR FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY, WASHINGTON, DC, ACCOMPANIED BY DONALD BAUER, PRINCIPAL DEPUTY TO THE ASSISTANT SECRETARY, DEPARTMENT OF ENERGY, AND JEREMIAH WALSH, DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT, PLANNING, AND TECHNICAL COORDINATION, FOSSIL ENERGY

Mr. Vaughan. I recognize the committee's time constraints this morning, so I will briefly emphasize some key points contained in the opening pages of my formal statement, and then attempt to answer any questions the committee may have.

I have with me at the table, on my left, your right, my principal deputy, Mr. Donald Bauer, and, on my right, your left, the Fossil Energy Deputy Assistant Secretary for Management, Mr. Jeremiah Walsh—both of these gentlemen have spent many hours over the last few months putting together what I consider to be a technologically sound and responsible budget proposal. I have also here with me other key members of the fossil energy staff to assist in the event we would need to go into great detail in responding to your questions.

Mr. Chairman, our budget today attempts to strike a balance between the urgency of limiting Government spending and the necessity of maintaining a sound, progressive program of long-range, high-risk, generic research and development.

The administration is requesting some $242.7 million in total budget authority for fossil energy research and development in fiscal 1986. Approximately $156.9 million of that amount is for new budget authority; the remainder is made up of funding available from previous years.

The overriding fiscal priorities that guided our budget preparation meant, in some cases, that not all legitimate, technologically sound energy concepts can be pursued. But these difficult decisions have preserved a fossil energy budget that is both technologically defensible and fiscally sound. The fundamental core of our program—the basic and applied research which we believe to be the most effective and appropriate use of public dollars—remains intact.

In examining the administration's proposals for the fiscal year 1986 fossil energy program, six major points are particularly important:

(1) EMPHASIS CONTINUES TO BE PLACED ON DEVELOPING NEW ENVIRONMENTALLY CLEAN, ECONOMICALLY EFFICIENT CONCEPTS FOR COAL

Approximately 80 percent of the funds requested for fossil energy research and development, excluding program direction and management support, would be spent to develop new coal-based options. This is consistent with the potential offered by this abundant national resource—coal accounts, as this committee knows, for more than 80 percent of the Nation's recoverable fossil fuel reserves.

(2) THE PROPOSAL CONTAINS ONLY THOSE PROGRAMS WHICH ARE UNQUESTIONABLY BEYOND THE SCOPE OF PRIVATE SECTOR INITIATIVE

Nearly 65 percent of the fiscal 1986 fossil energy budget proposal, excluding program direction and management support, would be directed at applied research.

The remaining 23 percent would focus on selected projects, including proof-of-concept efforts—the final stage of federally funded R&D as this administration sees it.

(3) THE PROPOSAL REPRESENTS A RELATIVELY STABLE FUNDING PATTERN FOR FEDERALLY SPONSORED FOSSIL ENERGY RESEARCH

While we recognize that the budget proposed for fiscal 1986 is approximately $100 million less than the 1985 congressionally appropriated level, our request nonetheless represents only an 11-percent reduction from the budget submitted by the administration last year. We believe this reduction is well within the boundaries of responsible program management given the fiscal constraints that confront us.

(4) THE PROPOSED FOSSIL ENERGY PROGRAM CONTINUES TO MAINTAIN A BALANCED MIX OF FUNDING RECIPIENTS

The ultimate customer of federally sponsored fossil energy technology is the private sector. In this regard, we continue to emphasize the need to involve private industry and academia as its research partners. In fiscal 1986, private industrial and academic research facilities would receive 57 percent of the available funds. The remainder would be spent in-house or at national laboratories.

(5) EMPHASIS CONTINUES TO BE GIVEN TO COST SHARING WITHIN THE PRIVATE SECTOR

Private sector financial participation in the fossil energy R&D program serves a dual purpose:

First, it gives the Government the ability to leverage limited tax dollars while providing a strong indication of industrial support and commitment to a technology; and second, it facilitates the transfer of new concepts into commercial development and application.

The fiscal year 1986 fossil energy budget, therefore, continues a strong emphasis on private sector cost-sharing.

(6) A MAJOR COMPONENT OF THE BUDGET CONTINUES TO BE DIRECTED AT ENHANCING THE ENVIRONMENTAL ACCEPTABILITY OF COAL, PARTICULARLY IN LIGHT OF CONCERNS ABOUT ACID RAIN

The fiscal 1986 budget request continues a strong research program in acid-rain-related technologies, consistent in scope with the fiscal 1985 effort. Approximately $53 million would be applied to technologies specifically designed to remove suspected acid-rain-causing pollutants. An approximately equal amount is proposed for technologies that will inherently result in lower sulfur dioxide or nitrogen oxide emissions compared to the conventional technologies they would replace.

This concludes my opening statement, Mr. Chairman. I would be pleased to answer any questions you may have.

[The prepared statement of Mr. Vaughan follows:]

THE FY 1986 FOSSIL ENERGY BUDGET PROPOSAL

Statement of
William A. Vaughan
Assistant Secretary for Fossil Energy
U.S. Department of Energy
to the
Subcommittee on Energy Development and Applications
House Committee on Science and Technology
March 6, 1985

Mr. Chairman and Members of the Committee:

The President's fiscal 1986 budget request for fossil energy research and development strikes a balance between the economic urgency of limiting government spending and the technological necessity of maintaining a sound, progressive program of long-range, high-risk, generic R&D.

The Administration is requesting $242.7 million in total Budget Authority for fossil energy research and development in fiscal 1986. Approximately $156.9 million of that amount is for new BA; the remainder is made up of funding available from previous years.

The budget request is divided among the major fossil energy resource categories as follows:

Coal	$ 148.8 million
Petroleum	27.4 million
Unconventional Gas	8.9 million

In addition, $57.6 million is proposed for Program Direction and Management Support at the Department's headquarters, Energy Technology Centers, and Project Offices.

The decisions reflected in this budget request have been made within the context of the urgent national need to reduce federal spending. This overriding fiscal priority has meant, in some cases, that not all legitimate, technologically sound energy concepts can be pursued. For some processes, particularly those in more advanced stages of maturity, it has meant that federal involvement cannot proceed as far down the development path as might be possible under different economic conditions. And for some efforts, particularly those that require major capital outlays for large facilities, fiscal considerations have necessitated that the government offer equipment and facilities in lieu of direct funding.

But these difficult decisions have preserved a fossil energy budget that is both technologically defensible and fiscally sound. The fundamental core of our program — the basic and applied research which we believe represents the most effective and appropriate use of public dollars — remains intact.

We urge the Congress to review this budget proposal within this context, from the perspective of fiscal responsibility as well as with a view towards the prospects offered by the proposed program for long-range technological benefit. Both are equally important to the future wellbeing of this nation.

Major Elements of the FY 1986 Proposed Fossil Energy Program

In examining the Administration's proposals for the FY1986 Fossil Energy program, six major points are particularly important:

(1) Emphasis continues to be placed on developing new, environmentally clean, economically efficient concepts for coal.

Approximately 80 percent of the funds requested for fossil energy research and development (excluding program direction and management support) would be spent to develop new **coal-based** options. This is consistent with the potential offered by this abundant national resource -- coal accounts for more than 80 percent of the nation's recoverable fossil fuel reserves.

However, significant funding has also been made available to gas-related technologies, some of which are included within the coal portion of the budget (i.e., surface and underground coal gasification, gas-stream cleanup, fuel cell research, etc.); and to petroleum-related efforts, where research in advanced process technology, enhanced oil recovery and oil shale has been oriented to more fundamental research that could foster new ideas, and eventually, new processes and technologies.

(2) The proposal contains only those programs which are unquestionably beyond the scope of private sector initiative.

Nearly 65 percent of the fiscal 1986 fossil energy budget proposal (excluding program direction and management support) would be directed at applied research. At this stage, the broad engineering and physical science aspects of fossil energy technologies would be studied. Another 12 percent of the budget would be applied to basic research where the emphasis is on obtaining a more fundamental understanding of physical and chemical mechanisms of fossil fuel processes. The remaining 23 percent would focus on selected projects, including proof-of-concept efforts, that apply knowledge and engineering principles to specific fossil energy devices, systems, materials or processes. This is the final federally funded stage of R&D prior to industry assuming the responsibility for further development and commercialization.

(3) The proposal represents a relatively stable funding pattern for federally sponsored fossil energy research.

While we recognize that the budget proposed for fiscal 1986 is approximately $100 million less than the 1985 Congressionally appropriated level, our request nonetheless represents only an 11 percent reduction from the budget submitted by the Administration last year. Given the severe fiscal constraints that confront the nation, we believe this reduction is well within the boundaries of responsible program management.

(4) The proposed fossil energy program continues to maintain a balanced mix of funding recipients.

The ultimate customer of federally sponsored fossil energy technology is the private sector. In this regard, the fossil energy program continues to emphasize the need to involve private industry and academia as its research partners. In fiscal 1986, under our proposed budget, private industrial and academic research facilities would receive 57 percent of the available funds, as shown in the following chart:

Recipient	FY 1986 Proposed Budget ($ in millions) Coal	Petroleum	Gas
Industry	$ 76.9	$ 27.4	$ 8.9
Colleges/Universities	23.0	2.8	0.4
Private Sector	99.9	30.2	9.3
National Laboratories	17.9	5.1	4.7
In-House R&D & Management Support	63.3	9.0	3.2

5) Emphasis continues to be given to cost-sharing with the private sector.

Private sector financial participation in the fossil energy R&D program serves a dual purpose: one, it gives the government the ability to leverage limited tax dollars while providing a strong indication of industrial support and commitment to a technology; and two, it facilitates the transfer of new concepts into commercial development and application. The FY 1986 fossil energy budget, therefore, continues a strong emphasis on private sector cost-sharing.

Thirty-six individual Fossil Energy programs and projects proposed for nearly $47.5 million of federal funding in fiscal 1986 would, in turn, attract private cost-sharing totaling more than $42 million. (These figures are current projections and could increase further as contracts are negotiated in fiscal 1986.) In addition, the $15 million advance appropriation for the EPRI/TVA fluidized bed demonstration plant (plus an identical amount appropriated in FY 1985) would supplement nearly $190 million to be provided by the private sector.

(6) A major component of the budget continues to be directed at enhancing the environmental acceptability of coal, particularly in light of concerns about acid rain.

The fiscal 1986 budget request continues a strong research program in acid rain related technologies, consistent in scope with the fiscal 1985 effort. The fiscal 1984, 1985, and 1986 funding levels for acid rain related research conducted by the Office of Fossil Energy are shown on the following chart:

FOSSIL ENERGY ACID RAIN PRECURSOR CONTROL ACTIVITIES

($ in millions)

	Actual 1984	Approp. 1985	Request 1986
Control Technology & Coal Preparation	$ 25.6	$ 35.1	$ 27.2
Combustion Systems			
Atmospheric Fluid. Bed	1.4	3.7	2.3
TVA/EPRI Fluid. Bed	0	15.0	15.0
Pressurized Fluid. Bed	7.4	2.5	5.2
Advanced Combustion	1.7	2.0	2.5
Interagency Task Force on Acid Precipitation	.26	.74	.75
Total	$ 36.36	59.04	52.95

In addition to the $52.95 million requested in fiscal 1986 for acid rain precursor control technologies, an approximately equal amount is proposed for technologies (e.g. fuel cells, gasification) that will inherently result in lower sulfur dioxide and/or nitrogen oxide emissions than the conventional technologies they would replace.

The following pages describe in more detail the President's fiscal 1986 budget proposal for fossil energy research and development:

COAL

Control Technology & Coal Preparation

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 25.6	$ 35.1	$ 27.2

The ultimate cost of electricity, process heat, or shaft horsepower is strongly dependent on technologies dealing with coal quality, environmental emissions, and waste disposal. A sound advanced technology base in the interdependent technologies of coal beneficiation, gas cleaning, and waste disposal is necessary to achieve the highest degree of cost effectiveness for the expanded use of domestic coals.

This activity includes four interconnected subactivities: (1) Coal Preparation; (2) Flue Gas Cleanup; (3) Gas Stream Cleanup; and (4) Waste Management.

The coal preparation program is developing advanced coal cleaning technologies that will reduce the ash and sulfur content of U.S. coals to produce a coal-based fuel with sufficient environmental quality to replace oil and/or natural gas in both utility and industrial applications and to reduce emissions of suspected acid rain precursors from coal-fired power plants in both new and retrofit applications. In fiscal 1986, with a proposed budget of $10.3 million, this subactivity would:

- Complete, in cooperation with EPRI at the Homer City, PA, Coal Cleaning Test Facility, the first phase of testing of several advanced physical cleaning processes which have the potential for significant pyritic sulfur removal;
- Complete in-house benchscale testing of physical coal cleaning by selective coalescence and column flotation techniques, and determine readiness for testing at the EPRI Coal Cleaning Test Facility;

- Initiate proof-of-concept (500-1000 lbs/hr) design of a selected continuous coal cleaning system based on results of 20 lb/hr benchscale tests. The selected system would be based either on the fused salt or microwave cleaning concept. Cost sharing is anticipated;
- Complete a study begun with the issuance of a Request-for-Proposals in FY 1985 to determine fully the feasibility of biotechnology (i.e., microorganisms) for removing organic sulfur from coal;
- Begin research on slurry rheology and stability of low-rank coals and pilot plant vacuum filtration test work.

The flue gas cleanup program addresses the removal of pollution causing contaminants from the stack gases of conventional combustion units. The goal is to improve the capability of removing flue gas pollutants in new plants built in compliance with today's emission standards as well as to develop an economic means for reducing air pollutants from existing, uncontrolled coal-fired boilers.

Efforts are focused on advanced processes that combine nitrogen oxide, sulfur dioxide, and particulate removal, both for utility and industrial applications. The FY 1986 budget would be $10.1 million and would:

- Complete the testing and evaluation of the electron-beam/ammonia-producing advanced scrubber concept now being tested at an Indianapolis Power and Light power plant;
- Continue "proof-of-concept" testing of the fluidized bed copper oxide stack gas scrubbing process;
- Continue "proof-of-concept" testing of the low-cost, modest performance acid rain precursor control candidate technologies;
- Continue research on advanced SO_x/NO_x cleanup concepts, thermodynamics, and control techniques for fine particles and volatile organic compounds;
- Conduct advanced SO_x/NO_x chemistry R&D.

Gas stream cleanup includes technologies for removing contaminants from coal gasifier and combustor processes before the gases are used in advanced power cycles such as gas turbines and fuel cells. Both hardware and environmental protection are key elements in this subactivity. Using $5.6 million in requested funds, this program would:

- Complete sub-pilot scale testing of candidate particulate removal (at New York University) and alkali control devices (at Morgantown Energy Technology Center) for pressurized fluidized bed combustors;
- Begin a program to select cleanup devices for "proof of concept" integration with a pressurized fluidized bed combustion system;
- Conduct particulate and alkali cleanup evaluation efforts for coal gasification using pressurized fluidized bed combustion and gasification data as a reference baseline;
- Complete gasification benchscale particulate removal tests and begin sub-pilot scale tests;
- Conduct gasification alkali and H_2S control tests;
- Conduct research to control potential gasification contaminants for molten carbonate fuel cells;
- Complete zinc ferrite sorbent testing for sulfur removal for molten carbonate fuel cells at sub-pilot level;
- Complete testing of soot and particulate control for molten carbonate fuel cells;
- Continue tests of selected concepts for controlling trace contaminants by combustion modifications;
- Continue to investigate chemical and physical properties of contaminants to quantify and qualify specific species of interest.

Waste management research focuses primarily on waste sampling, characterization and disposal with a specific emphasis placed on the wastes produced by advanced technologies being developed elsewhere in the federal fossil energy program. The proposed FY1986 program would be funded at $1.2 million and would:

- Complete the data base for the leachate attenuation of low rank coal wastes;
- Continue research on extracting energy from coal preparation wastes so that the resulting wastes are benign;
- Continue sampling and characterizing organic and inorganic species in solid wastes produced by emerging technologies;
- Continue field studies to monitor advanced coal utilization processes waste disposal sites.

Advanced Research and Technology Development

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 39.0	$ 39.9	$ 32.9

The Advanced Research and Technology Development (AR&TD) budget for fiscal 1986 maintains the Administration's commitment to continuing federally-sponsored research into the fundamental scientific and technical areas that underlie all fossil energy concepts. The apparent decrease in requested funding for fiscal 1986 is due to the budgeting of the Processes subactivity, which focuses on the fundamental mechanisms of converting coal to synthetic liquid and gaseous fuels, with the Liquefaction and Gasification program elements. Congress directed this change in the Conference Report accompanying the fiscal 1985 appropriations act.

The FY 1986 AR&TD program has been fashioned in direct response to research needs identified by the Energy Research Advisory Board, various Fossil Energy research working groups, the National Academy of Sciences, and others.

The AR&TD program is unique in that it addresses specific scientific and technical areas which are more generic than the Fossil Energy line programs, yet which are oriented specifically to long-range Fossil Energy objectives (as contrasted with the non-technology specific nature of the basic research program supported by the Department's Office of Energy Research).

Four major subactivities make up the FY 1986 AR&TD program: (1) Direct Utilization; (2) Materials and Components; (3) Technology Crosscut; and (4) University Coal Research.

The **direct utilization** subactivity involves the study of fundamental properties associated with coal combustion, preparation, slurries, gas cleanup and fuel cell applications. In fiscal 1986, projects in this category would receive $10.9 million and would:

- Continue research in combustion kinetics and pyrolysis, and the formation of SO_x and NO_x in boilers;
- Expand the study of coal preparation and beneficiation science and of novel concepts for pollutant removal in boilers;
- Continue research into ash effects and the fate of mineral matter in coal utilization processes;
- Continue investigation of coal-water slurry rheology;
- Continue studies of fluidized bed particle efflux and erosion;
- Continue studies of pressurized combustion and deposition mechanisms in advanced combustion concepts;
- Conclude prior year studies in hot gas cleanup methods;
- Continue generic electrochemistry studies pertinent to molten carbonate and solid oxide fuel cells.

The **materials and components** subactivity would be funded at $9.0 million in fiscal 1986 and would:

Materials

- Continue development of techniques for real-time, non-destructive examination of structural ceramics;
- Conduct analysis of the combined effects of cyclic and static stress and environment on the deterioration of coal conversion heat exchanger materials;
- Analyze mechanisms of toughening and crack propagation in ceramic composites;
- Analyze the mechanisms of deterioration of the mechanical properties of refractories by slag;

Components

- Continue research to understand better the mechanisms of discrete particle flow;
- Conduct studies of the stability and rheology of suspension systems such as those occurring in coal-liquid mixtures;
- Continue modeling and scaleup technique development for suspension transport systems.

The **technology crosscut** subactivity provides the necessary studies and evaluations of the Fossil Energy program to ensure that it meets environmental, technical, and economic policy goals. This category provides the funding for the Office of Fossil Energy's participation in the Interagency Task Force on Acid Precipitation and in several activities supported by the International Energy Agency. Projects are also included to develop unique methods of instrumentation, control and diagnostics. In fiscal 1986, these cross-cutting efforts would be funded at $7.0 million and would include:

Environmental Activities

- Analyses of air and water quality, solid waste disposal, and toxic substances as well as services to ensure occupational health and safety;
- Continued research into manmade sources of acid rain precursors as part of the Interagency Task Force on Acid Precipitation;

Technical and Economic Analyses

- Studies to support multi-year planning and Fossil Energy strategy and program formulation, cross-cutting technical/economic assessments, and support of International Energy Agency activities;

Technology Base Synthesis

- Assessments of Fossil Energy programs in support of international projects and agreements and identification of advanced research needs;

Instrumentation, Control, and Diagnostics

- Exploration of unique methods to measure multiphase flow parameters such as void fraction, velocity, solids content, and viscosity; and identification of techniques such as plasma spectrographic methods to measure chemical species.

The **university coal research program** would be funded for its seventh consecutive year under the fiscal 1986 budget request, and the amount proposed would constitute the largest funding allotment for this activity in the program's history. Some $5.9 million would be made available to:

- Initiate approximately 30 new university projects related to coal science, environmental science, surface science, organic and inorganic chemistry of coal constituents, and the mechanisms and kinetics of gasification, liquefaction and combustion.

Coal Liquefaction

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 28.8	$ 25.8	$ 19.4

Under the fiscal 1986 budget proposal, the Coal Liquefaction program would continue to add to the federal data base which is available to the private sector to develop processes for converting U.S. coals to liquid fuels.

Coal liquefaction, when combined with petroleum refining technology, could provide direct replacement products for petroleum used in heating and transportation. Innovative improvements will be needed, however, to improve the market potential of liquefaction technologies.

In fiscal 1986, several larger scale "proof of concept" tests will have been completed -- tests of the integrated two-stage liquefaction concept will be concluded in 1985 at the Wilsonville, Ala., test facility; the liquid phase synthesis technique for syngas conversion will have been tested at LaPorte, Tex.; and the production of olefins (which can be converted to diesel fuel) from methanol will have been evaluated at the modified methanol-to-gasoline pilot plant in Germany (using prior year funds).

Consequently, the fiscal 1986 program will focus on more generic, less expensive research primarily at the laboratory and bench scales. Included in this program, for the first time, will be the liquefaction-related efforts previously included in the Advanced Research & Technology Development activity.

Specifically, the fiscal 1986 liquefaction program would be comprised of (1) advanced research; (2) indirect liquefaction; (3) advanced process development (direct liquefaction); and (4) support studies/engineering evaluations.

The **advanced research** subactivity involves fundamental studies of liquefaction budgeted in prior years within the AR&TD program. The proposed funding level for fiscal 1986 is $5.1 million which would be used to conduct studies in:

- Innovative process concepts and techniques for controlling parameters in coal liquefaction and advanced catalysis;
- Biological approaches to coal liquefaction;
- New and evolving concepts in catalyzing coal liquefaction reactions, such as the use of immobilized homogeneous catalysts and cluster catalysts.

The objective of the **indirect liquefaction** program continues to be to develop the basic concepts for converting high carbon monoxide content synthesis gas (typical of the gas produced by advanced coal gasifiers) into quality fuels, preferably without the extensive downstream processing required in the past. In fiscal 1986, this subactivity would be funded at $4.4 million and would include:

- Continuation of previously awarded cost-shared industrial indirect liquefaction contracts that have shown encouraging results;
- Continued laboratory research to expand the knowledge of catalyst and reaction systems.

The **advanced process development** subactivity continues to support innovative improvements in direct coal liquefaction that could significantly reduce costs. With a substantial data base now existing for the integrated two-stage liquefaction concept following four years (fiscal 1982-85) of testing at the Wilsonville unit, this $5.6 million subactivity in fiscal 1986 will focus on:

- Continued laboratory and benchscale research on innovative direct liquefaction concepts such as "co-processing" of coal with heavy petroleum oils. Co-processing research, begun by the Department last year, could lead to cost reductions and accelerated introduction of coal-derived fuels into the market by using petroleum refining technology and equipment.

The **support studies/engineering evaluations** subactivity would receive $4.3 million in fiscal 1986 which would be directed at:

- Biomedical studies with an emphasis on the products of "co-processing" (see Advanced Process Development);
- Liquefaction data base management, research guidance studies and instrument and component research;
- Research emphasizing solvent quality characterization, reaction kinetics, and catalyst deactivation.

Combustion Systems	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 18.1	$ 30.2	$ 29.2

Generic technology base development on advanced coal and coal-derived combustion concepts is the focus of the Combustion Systems activity. This research will help establish the technology base from which industry can develop and deploy improved coal utilization systems that are compatible with national environmental objectives. The principal programs in this activity are (1) atmospheric fluidized bed combustion, (2) pressurized fluidized bed combustion, (3) advanced combustion technology, and (4) alternative fuels.

The **atmospheric fluidized bed combustion** program, proposed for funding at $17.3 million in fiscal 1986, is comprised of these major elements:

- The Tennessee Valley Authority/Electric Power Research Institute fluidized bed demonstration plant. The Department is providing $15 million in FY 1986 for support of test plans and data from plant operations using a deferred Congressional fiscal 1984 appropriation;
- Solicitation of concepts for special applications in commercial/institutional and residential markets;
- Benchscale testing of advanced concepts, in-house studies and data evaluation, and special application studies.

The **pressurized fluidized bed combustion** program would be funded at $5.2 million in fiscal 1986. Emphasis will continue to shift from first-generation steam-cooled systems to more advanced cycle concepts, although the Department will maintain a technology base activity to resolve key technical uncertainties for the earlier systems. Elements of the program to receive specific attention are:

- Metal wastage investigations to verify the mechanisms and kinetics of coal/sorbent combustion products, particle energies and materials survivability;
- A cost-shared program at the Grimethorpe test facility in Great Britain to test key critical PFB process components for reliability and operability in support of first-generation systems;
- Award of a cost-shared contract for a definitional study of a high efficiency, second-generation PFB system which could improve process economics, reliability, operability and environmental performance.

The **advanced combustion technology** program is attempting to fire coal or coal-liquid mixtures directly in existing or new oil/gas designed boilers and process heaters with a minimum of derating. The successful outcome of this effort will depend on the success the program has in removing the ash (or slag) from the coal-based fuel in a precombustion stage, as well as sulfur removal at some point in the combustion system. In FY 1986, this effort would be funded at $2.5 million and would:

- Complete the design of a retrofit external slagging combustor (AVCO concept);
- Complete testing of an advanced slagging combustor (TRW concept);
- Complete a market study and economic analysis of advanced combustor potential;
- Complete testing of the most promising innovative concepts;
- Select and begin testing concepts most applicable to commercial/residential uses.

The **alternative fuels** program objective is to establish the technology base, specifically in the area of combustion phenomena (as contrasted with fuel preparation) for coal-liquid mixtures. With the federal portion of the data base now essentially complete for coal-water mixtures applied to large industrial and utility boilers, the effort, proposed for funding at $4.2 million in fiscal 1986, would:

- Begin generic combustion characterization for coal-liquid mixtures comprised of ultra clean, micron-size coal. These fuels could be most suitable for small industrial, residential, commercial and institutional boilers/furnaces.

Fuel Cells

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 42.3	$ 40.8	$ 9.3

Fuel cells are electrochemical conversion systems which are highly efficient, fuel flexible, modular, and environmentally attractive. The potential exists to apply fuel cell power systems to central baseload electric utility plants, on-site cogenerating systems, transportation and defense installations. The role of the federal government in this technology is viewed as most appropriately focused on high-risk, high-payoff technology base development, as well as assisting industry in developing techniques to apply hydrocarbon conversion technology to this power generating concept.

Three subactivities make up the fuel cell program: (1) Phosphoric Acid Systems; (2) Molten Carbonate Systems; and (3) Advanced Concepts.

More than $300 million in federal funding invested during the last 10 years has helped establish the technical feasibility of **phosphoric acid** fuel cells powered by natural gas and naphtha. By 1986, the technology for the phosphoric acid fuel cell will have advanced well beyond the "proof-of-concept" stage; therefore, the Department believes that continued development or commercial demonstration should be the responsibility of industry and has proposed no federal funding for this activity.

Advanced "second-generation" **molten carbonate** fuel cell technology trails phosphoric acid development by several years. Nonetheless it offers the potential for increased efficiency and reduced costs. To continue the federal role in developing this type of fuel cell, the Department proposes to spend $6.4 million in fiscal 1986 to:

- Begin verification testing of molten carbonate fuel cell performance in full area short stacks;
- Conduct technology base research on the tolerance of fuel cell electrodes to contaminants and corrosion that could be possible when the system is linked to a coal gasifier;
- Conduct initial verification of the suitability of cathode materials.

Advanced concepts for fuel cells principally include the solid oxide electrolyte concept which offers the advantage of solid state stability and potentially low manufacturing costs. Efforts to develop this concept would be funded at $2.9 million in fiscal 1986 and would focus on:

- System studies to verify economic viability and studies of fuel cell fabrication technology;
- Continued R&D to qualify a 5 kilowatt preprototype module through a 10,000+ hour test run;
- Start of a modest effort to study internal fuel reforming in solid oxide cells.
- Selected technology base efforts;

Heat Engines

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 6.5	$ 11.9	$ 11.4

Directly firing a highly-beneficiated, finely ground coal, either dry or suspended in a liquid, or a coal-derived gas cleaned at minimal cost is the long-term goal of the Heat Engines program. If this objective can be achieved, coal could penetrate the gas turbine market, with its inherent advantages of efficient, low-cost and highly-flexible power generation, or the diesel power market which has been penalized by rising distillate fuel costs.

To establish the technical data base needed for the use of coal in these applications, the fiscal 1986 program, budgeted for $11.4 million, would:

- Establish reference fuel quality specifications for integrated development of coal-fired gas turbine components;
- Define design and performance boundary conditions for integrated gas turbine component development and test program;
- Establish basic design and fuel criteria for preliminary design, development, and test evaluation of coal-fired diesel components; and
- Complete preliminary analyses of coal-fired diesel engines in selected propulsion and stationary power applications.

Underground Coal Gasification

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 6.0	$ 5.8	$ 4.3

Underground coal gasification is a method of producing readily cleanable fuels by gasifying seams of coal "in situ" (in place) without mining. The potential exists to greatly expand U.S. coal usage while providing fuels at lower costs and with less adverse environmental impacts than other conventional or synthetic fuel options.

The Department's underground coal gasification program consists of two subactivities: (1) gasification technology development, and (2) environmental and advanced research.

Successful completion of **gasification technology base** activities for underground gasification of medium-ash, subbituminous coal beds has brought the technology to the point where industry is prepared to move forward with a substantial cost-shared test. This aspect of the underground gasification program, therefore, would be funded at $2.5 million in fiscal 1986 with the principal objectives of:

- o Completing the installation of field facilities for a 100-day, parallel row field test (using the Controlled Retracting Injection Point process) in subbituminous coal. Tests to be equally cost-shared with industry funds provided through the Gas Research Institute;
- o Modeling and supporting research for the subbituminous field test and the investigation of applications of the data to other coal types;
- o Continuation of international technology transfer.

Some generation of contaminants is inherent to the partial combustion and gasification of coal underground; therefore, the Department is continuing a significant effort in **environmental and advanced research**. In fiscal 1986, this subactivity would be funded at $1.8 million and would involve:

- o Post-burn environmental monitoring and mitigation efforts in conjunction with state environmental quality agencies;
- o Determining how (and what) pollutants migrate to adjacent aquifers and developing mitigation strategies.

Magnetohydrodynamics

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 29.9	$ 31.0	$ 0

The Department proposes to phase out federal funding for the Magnetohydrodynamics (MHD) program beginning in fiscal 1985. The MHD program is a costly, long-range, high-risk effort. The high costs of large-scale engineering facilities necessary to prove the technical concept of this advanced power generating option makes MHD an unaffordable option during a time of severe fiscal constraints.

To facilitate the phase out of the Department's efforts, plans will be made in fiscal 1985 to make the large amount of Government-owned equipment and facilities available to the private sector in a manner that will permit industry to continue the development of the technology if it so chooses. The federal government has invested approximately $100 million in the Component Development and Integration Facility in Butte, Montana, and nearly $50 million in the Coal-Fired Flow Facility in Tullahoma, Tennessee. Overall, more than $500 million has been spent by the federal government in the last decade on MHD research. These government-financed facilities, plus the substantial technology base developed through federally-sponsored projects, should provide the private sector with the necessary information to make future development decisions about this technology.

Surface Coal Gasification

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 36.5	$ 32.0	$ 15.0

Through gasification, coal can be used for the manufacture of fuel gases having heating values that range from low/medium-Btu fuel gas for industrial and electric utility uses to high-Btu, pipeline-quality gas that can supplement supplies of natural gas. Gasification technology also can be used to produce a synthesis gas for subsequent conversion into a variety of liquid fuels or chemicals.

The Department's Surface Coal Gasification program is assisting industry in advancing the state-of-the-art of coal gasification through several parallel efforts. A technology data base is being developed which will permit the private sector to conduct normal risk assessments upon which to base commercialization decisions. Existing gasification systems are being refined through a generic research and development program, and new concepts are being examined through small-scale resesarch and engineering tests.

Five major subactivities make up the Surface Coal Gasification program: (1) Advanced Research (which was budgeted within the Advanced Research & Technology Development program in past fiscal years); (2) Advanced Process Development; (3) Systems Engineering Concepts; (4) Environmental Studies and Engineering Analyses; and (5) Great Plains Gasification Project monitoring.

The **advanced research** subactivity produces the fundamental data on gasification phenomena (i.e., reaction mechanisms, kinetics, physical properties, yields, heat rates, thermodynamics, etc.) needed to identify potential new approaches to gasifying coal. Projects in this category also contribute essential information for the preparation of a sound data base. The proposed funding level for fiscal 1986 is $3.5 million which would be used to conduct studies in:

- Coal softening, including modeling of mass transfer, and ash softening, including ash agglomeration, reaction kinetics, and mechanisms;
- Gasification modeling incorporating multiphase flow, coal and ash softening and agglomeration, and heterogeneous reactions;
- Heating rates for pyrolysis with the objective of developing an integrated model to predict coal pyrolysis phenomena from raw coal measurements;

- Novel approaches to gasification and gas separation;
- Catalytic upgrading of synthesis gas to enhance hydrogen recovery;
- Kinetics of coal devolatilization using computer models, and the effects of temperature and pressure on fines production in fluid bed reactors;

The major objective of the **advanced process development** effort is to continue the development of new and unique concepts that can significantly improve the gasification process. Particular emphasis is being placed on reducing the number of processing steps, optimizing existing technology, and increasing the flexibility and/or applicability of the gasification process. Proposed for funding at $3.3 million in fiscal 1986, this effort will:

- Continue operation of an advanced gasification concepts facility to generate data on advanced entrained gasification and hot gas cleanup technology;
- Continue investigation of high pressure, high temperature fluidized bed gasification;
- Continue studies of advanced coal gas cleanup processes and investigate applications of new coal chemistry techniques.
- Continue studies to identify and determine the potential for separating complex gas mixtures with the objective of selectively removing impurities;
- Continue studies on advanced stage concurrent or rapid rate gasifiers/gasification processes that could vary or optimize product yields;
- Continue theoretical studies on coal gasifiers and gasification systems needed to design an optimized systems/technology data base.

Improving the entire gasification system -- from the "upstream" production of gasification reactants, such as oxygen, to the "downstream" cleanup of the synthetic gas — is the objective of the **systems engineering concepts** subactivity. With a proposed funding level of $3.2 million, the fiscal 1986 efforts in this category will continue:

- Development of a solid state electrolyte (zirconia) oxygen separator concept;
- Identification, development and evaluation of hybrid gasifiers (e.g., two-stage pyrolysis/gasification, gasification/combustion gasifiers, etc.);
- Studies of innovative techniques for in-line measuring of process parameters/gas compositions essential to process control and evaluation;
- Benchscale studies of high-pressure systems using composite sorbents for cleaning gas streams;
- Development of promising alternative concepts for existing components, units, systems, etc. that have high failure rates or high capital and maintenance costs;
- Novel fabrication techniques that could reduce construction costs of gasification facilities;
- Studies on the integration of gasifiers/gasification technologies with other conversion systems to determine optimum configurations and to identify future R&D needs.

An important source of fundamental data for future gasification facilities is being generated today by the **environmental studies and engineering analyses** subactivity. Using $2.2 million in proposed fiscal 1986 funding, this effort would:

- Identify and develop process modifications to reduce the generation of trace hazardous compounds;
- Continue studies on environmental aspects of coal gasification, including waste water management, effluent control systems, and the impact of gasification plant environments on worker health;
- Continue study of novel approaches to using micro-organisms for removing trace amounts of organic contaminants in waste water;
- Continue to improve quality of data base and analytic models and increase the ability of end users to analyze new systems.

The **Great Plains Coal Gasification Project** is expected to be in full operation during fiscal 1986, having passed several start-up milestones in 1984 and 1985. The initial synthetic natural gas from this pioneering, commercial-scale facility was delivered to the pipeline on July 28, 1984, and since October 16, 1984, synthetic natural gas has been fed daily into the pipeline grid. The proposed $2.8 million funding level for this activity would:

- Continue management of the loan guarantee and the monitoring of the Great Plains Project.

PETROLEUM

Advanced Process Technology

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 5.0	$ 5.4	$ 5.8

The goal of the Advanced Process Technology (APT) program is to identify and develop crosscutting advanced extraction, processing, and environmental concepts and technology related to oil, gas, tar sands, and shale. Major programs include the investigation of novel and innovative extraction concepts as well as fundamental petroleum chemistry and extraction technology research or reservoir rock mechanics. Crosscutting advanced environmental research is also conducted to mitigate potential environmental constraints to the development of oil and gas technology. Specific initiatives are also being pursued to establish an Alaskan Arctic oil and gas data base and to provide industry with data on ice mechanics, seafloor stability, and permafrost that could accelerate Arctic oil and gas development.

Two major subactivities make up the APT program: (1) Advanced Exploratory Research; and (2) Arctic and Offshore Research.

The **advanced exploratory research** category would be funded at $4.7 million in fiscal 1986 and would include:

- Basic research into the novel use of micro-organisms to enhance oil recovery and field tests of promising microbes to determine nutrient requirements, transport characteristics, and oil release mechanisms;
- Fundamental petroleum chemistry research focusing on physical and chemical characterization studies of heavy oil;
- Thermodynamic measurements of individual nitrogen compounds in petroleum; studies of shale oil and tar sand bitumen degradation mechanisms and upgrading process studies and cooperative efforts with DOD to identify and solve fuel storage and handling stability problems;
- Extraction technology research focusing on reservoir characteristics and advanced instrumentation development;
- Extraction related studies to mitigate aquifer damage and subsidence problems;
- Fuels testing research, correlation of fuels composition and processing needs, and predictive modeling of process to composition.

The **arctic and offshore research** program, proposed for $1.1 million in fiscal 1986 funding, would:

- Continue to update and maintain the Arctic/offshore oil and gas research data base;
- Conduct fundamental ice research to characterize size, composition, degree of consolidation, temperature and salinity profiles.

Enhanced Oil Recovery

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 9.2	$ 11.8	$ 12.0

For the past 30 years, private industry has researched various enhanced oil recovery (EOR) techniques with mixed results. Because of the complexities of the subsurface behavior of injected fluids and chemicals, none of the EOR processes are well understood. While industrial research has concentrated on short-term, resource-specific targets, DOE's research program is oriented toward more fundamental, generic research which can improve the understanding and predictability of EOR processes.

Successful results from DOE's program could return substantial national benefits. Total crude oil resources in the U.S. are estimated at 481 billion barrels. Nearly 130 billion barrels have already been produced, and another 28 billion barrels are accessible through conventional primary and secondary production methods. Thus, two-thirds of the oil, approximately 323 billion barrels, will remain in the ground if no improvements can be made in today's conventional production technology. This, therefore, is the opportunity offered by EOR research.

Generic technology base R&D activities in the EOR program are divided into three subactivities: (1) Heavy Oil; (2) Light Oil; and (3) Tar Sands:

The **heavy oil** program would be funded at $2.9 million and would:

- Conduct theoretical studies of multiphase fluid flow using steam with foam for mobility control;
- Conduct research focusing on computer simulation of steam with additives and kinetics of oxygen-enriched in situ combustion;
- Continue mutually beneficial research with Venezuela and Mexico;
- Maintain heavy oil resource and thermal recovery national data base.

The **light oil** program, proposed for $7.7 million in FY 1986, would:

- Continue fundamental research into chemical and physical properties of surfactants;
- Conduct research focusing on CO_2 displacement mechanisms, mobility control, viscous fingering and mobilization of trapped oil by CO_2 and foam flooding/diverting concepts;
- Study geological parameters impacting EOR including determination of residual oil saturation in zones where EOR fluids can be injected; and micro- and macroscopic heterogeneities that cause channeling around residual oil;
- Conduct rock-fluid interaction studies including chemical adsorption and desorption, relative permeability, wettability effects, ion-exchange characteristics, surface chemistry, and chemical potential of sedimentary rocks;
- Maintain an integrated program of basic research at universities;
- Develop and maintain national EOR and light oil reservoir data bases.

The **tar sands** effort would be funded at $1.4 million and would:

- Continue joint research with Canada, including joint field tests, to study remote tracking of thermal fronts;
- Continue tests on large blocks of consolidated tar sands to determine oil production under a range of conditions;
- Continue fundamental studies on extraction, upgrading, kinetics, and environmental mitigation.

Oil Shale

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 16.1	$ 14.8	$ 9.7

The goal of the Department's oil shale R&D program is to develop a sound technology base to assist industry in selecting, developing and commercializing new technologies.

The oil shale resource in the U.S. is estimated to be the equivalent of two trillion barrels of crude oil. The richest reserves lie in the states of Colorado, Utah, and Wyoming in areas of high environmental sensitivity. Eastern shales are receiving increased industrial interest. Preliminary results from both government and industrial research indicate that the potential exists for substantial increases in liquid product yields through the use of advanced fluid bed or other novel process concepts. Therefore, in fiscal years 1983 and 1984, the Department conducted studies of the environmental chemistry involved when various eastern shales are processed. However, the overall processing chemistry and kinetics of eastern shales is poorly understood; therefore, in 1985, the program began to focus on developing a more complete understanding of eastern shale processing to place the environmental studies in a more meaningful framework.

The primary emphasis throughout the refocused oil shale program is on long-range, high-risk technology base research that is oriented around two basic subactivities: (1) Oil Shale Technology Base, and (2) Environmental Mitigation.

The **oil shale technology base** research effort would be funded at $5.8 million and would:

- Develop a systems analyses capability from mining to spent shale disposal;
- Continue experiments with both western and eastern shales using two reference retorts (one at the Morgantown Energy Technology Center; the other at Lawrence Livermore Laboratory) to provide data for modifying and developing chemical, physical, and economic models of generic, moving bed processes;
- Continue development and maintenance of an oil shale data base;
- Continue experiments to evaluate, modify, and/or develop predictive models for oil shale fragmentation and low-void retorting.

The **environmental mitigation** program would receive $3.9 million in fiscal 1986 and would:

- Continue to develop siting methodology;
- Continue development of the environmental data base;
- Conduct research on nitrogen emissions and the capture of sulfur by oil shale compounds under varying process conditions;
- Identify and measure major and trace element emissions in gases, liquids, and solids from reference retorts as a function of process parameters;
- Continue studies of critical questions associated with codisposal and spent shale pile stability.

UNCONVENTIONAL GAS

Unconventional Gas Recovery

	FY 1984	FY 1985	FY 1986
(Dollars in Millions)	$ 15.4	$ 10.2	$ 8.9

Natural gas currently supplies about 25 percent of the total energy consumed in the U.S.; however, for almost 10 years, the annual addition of gas reserves from new discoveries has been less than the withdrawals from existing reserves. In 1981, the trend was reversed, with additions surpassing withdrawals due to increased exploration resulting from partial decontrol of gas prices. Considerable conventional shallow and deep gas may be available for immediate use. Additional gas supplies, resulting from successful research on unconventional resources, combined with this conventional gas, could supply much of the nation's gas needs for well into the next century.

These unconventional sources of gas include eastern Devonian gas shales, western gas sands, methane from coalbeds, gas hydrates, and deep source gas. To provide a sound technology base for these potential sources, the Department's unconventional gas program is categorized by three major elements: (1) Eastern Gas Shales; (2) Western Tight Gas Sands; and (3) Environmental and Advanced Research.

The **eastern gas shales** effort would receive $1.0 million in fiscal 1986 which would be sufficient to:

- Drill a directional borehole at the second offset well test facility at a site to be selected in fiscal 1985;
- Continue development of the Eastern gas shale production data base and continue model refinement activities.

The **western tight gas sands** program, to be funded at a proposed $5.6 million would:

- Continue fracture stimulation research and production testing of a lenticular tight sands reservoir;
- Continue geologic/engineering studies of Uinta and Greater Green River basins;
- Continue supporting research in modeling, fracture diagnostics, and geophysical instrumentation.

The **environmental and advanced research** program would be funded at $2.3 million and would focus on:

- Resource identification and evaluation of gas hydrates;
- Geophysical diagnostic tests of gas hydrates on the North Slope of Alaska;
- Deep source gas research involving detection/differentiation systems and the mechanics of subduction zones.

PROGRAM DIRECTION AND MANAGEMENT SUPPORT

(Dollars in Millions)

	FY 1984	FY 1985	FY 1986
Operating Expense	$ 46.0	$ 43.0*	$ 50.6
Construction	1.6	4.4	3.0
Capital Equipment	5.0	4.9	4.0
	$ 52.6	$ 52.3	$ 57.6

* Net of $3,174,000 resulting from reductions under Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

The Program Direction and Management Support program includes management support for Headquarters and Energy Technology Center's program direction, capital equipment needs, and construction.

The Fossil Energy headquarters staff is responsible for overall direction for the coal, petroleum and gas research and development program. In carrying out this responsibility, the headquarters staff implements DOE policy and communicates that policy to the Energy Technology Centers and the Bartlesville Project Office, sets program objectives, develops program plans and evaluates alternative program strategies, develops and defends budget requests, approves procurement plans, and monitors work progress, evaluates projects, and approves revisions in work plans as required to attain program goals.

A total of 402 full-time equivalent (FTE) personnel are financed in the Program Direction and Management Support budget request, including 125 FTE's at Headquarters and 277 FTE's in the fossil energy field organizations. These positions carry responsibility for the management of multiple R&D program activities. An additional 197 FTE's, assigned solely to specific programs or projects, are funded as direct expenses within the individual program budgets.

The major elements of this line item are:

Management Support ....$ 50.6 million

- -- Headquarters and ETC program direction;
- -- Overhead expenses generic to the entire FE program which were financed in previous years by program assessments, i.e., technical report printing, historically black college funding allotment, small business innovative research funds, and general management support.

Institutional Investment ....$ 3.0 million

- -- Provides for centralized funding for Fossil Energy-related capital equipment needs at the Energy Technology Centers, National Laboratories, and the Bartlesville Project Office.

Construction ....$ 4.0 million

- -- Provide for general plant projects at ETC's.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY
FOSSIL ENERGY RESEARCH AND DEVELOPMENT
(In thousands of dollars)

	FY 1984 Actual		FY 1985 Estimate		FY 1986 Request	
	B/A	B/O	B/A	B/O	B/A	B/O
COAL:						
Control Technology and Coal Preparation	25,640	25,562	35,068	32,118	27,249	31,535
Advanced Research and Technology Development	38,996	38,880	39,924	36,560	32,872	38,043
Coal Liquefaction	28,800	23,696	25,815	29,643	19,386	25,864
Combustion Systems	18,080	18,026	30,218	21,439	29,243	31,483
Fuel Cells	42,310	42,183	40,811	37,380	9,342	10,812
Heat Engines	6,475	6,456	11,948	10,943	11,372	13,161
Underground Coal Gasification	6,000	5,982	5,753	5,269	4,260	4,930
Magnetohydrodynamics	29,867	29,777	30,977	28,372	...	5,000
Surface Coal Gasification	36,541	36,431	32,011	29,319	15,028	17,393
Subtotal Coal	232,709	226,993	252,525	231,043	148,752	178,221
PETROLEUM:						
Advanced Process Technology ..	5,000	4,985	5,409	4,954	5,778	6,687
Enhanced Oil Recovery	9,150	9,122	11,801	10,809	11,972	13,855
Oil Shale	16,050	16,002	14,751	13,511	9,675	11,197
Subtotal Petroleum	30,200	30,109	31,961	29,274	27,425	31,739
GAS:						
Unconventional Gas Recovery ..	15,400	15,354	10,227	9,367	8,872	10,268
PROGRAM DIRECTION AND MANAGEMENT SUPPORT:						
Program Direction and Management Support	53,163	52,525	52,347	49,325	57,622	64,614
Subtotal Fossil Energy R&D	331,472	324,981	347,060	319,009	242,671	284,842
FY 86 Prior Year Recoveries	...	...	...	...	-6,000	...
Prior Year Offsets	-27,326	...	-49,089	...	-60,838	...
Appropriation Transfers	-42,040	...	-11,300	...	-3,924	...
FY 85/86 Approp. made in FY 84 .	...	...	-15,000	...	-15,000	...
Proposed Section 2901 Rescission	...	...	3,276	...	...	...
TOTAL	$262,106	$324,981	$274,947	$319,009	$156,909	$284,842

DISCUSSION

Mr. **Fuqua**. Thank you, Bill. The budgets for fossil energy in the past several years have remained somewhat at a level amount. As we're all aware, it's been reduced considerably from the appropriated amounts of last year, the fiscal year we're in today. What's going to happen to these drastic reductions for people? How many people are going to be laid off or removed or eliminated ? Are any of the cost-shared programs you were talking about being affected by this?

Mr. **Vaughan**. Let me try to give you a succinct answer to your question, Mr. Chairman. As I indicated in my testimony, the proposal is $100 million roughly less than we were funded in 1985 appropriations. We do have deferrals pending for the bulk of that money. It is however only about 11-percent less than we requested for fiscal 1985 and were geared up to operate.

The essential things that will happen with these reductions is that essential technology base activities will continue; the bulk of the money came out of two programs, MHD and the phosphoric acid fuel cells, and account for nearly two-thirds of the reduction. When the MHD and the phosphoric acid fuel cells plus the deferrals are subtracted from the fiscal 1985 budget, the 1986 budget is only 2 or 3 percent below 1985 appropriated levels.

With respect to your question on manpower, in fiscal 1985, we were authorized 705 full-time equivalents, and in fiscal 1986, we are talking about 599. So we're essentially talking about slightly over 100 people. I believe that those personnel reductions are consistent with being able to keep up a viable technology program.

Mr. **Fuqua**. How about contract people? You mentioned 100 DOE people—how about contractor people?

Mr. **Vaughan**. Undoubtedly, there would be an effect, Mr. Chairman, but it would be very difficult for me to give you an answer on contract people.

Mr. **Fuqua**. Well, there are going to be some programs affected, such as in MHD and fuel cells, that are primarily being performed by contractors and others. Maybe you can provide that for the record if it is not readily available.

Mr. **Vaughan**. In MHD, Mr. Chairman, I do have the figures. There are about 440 people potentially involved. That would assume that nothing happens and everything shuts down. We are hopeful that, with respect to MHD, that making the facilities available to the private sector offers a chance to keep this technology effort going. Obviously, I can't answer the question as to whether that offer will work or not, because that depends on what the private sector responds.

Mr. **Fuqua**. Have you discussed this with the private sector?

Mr. **Vaughan**. We will discuss that at the first public meeting on MHD occurring in the month of April, Mr. Chairman.

Mr. **Fuqua**. When the budget decisions were made, that discussion had not taken place then.

Mr. **Vaughan**. No, it had not, Mr. Chairman.

Mr. **Fuqua**. So then you don't know that they will pick that up.

Mr. **Vaughan**. That's my point. I do not know what their capability or response will be.

Mr. **Fuqua**. In discussions we've had with industry and in going back to the hearings of last year, it is my understanding that it appeared that DOE was planning to upgrade the Butte MHD facility as a pilot plant. As a matter of fact, we had been encouraging that. It seemed to be the next logical step. Now it appears, that is being abandoned and I'm wondering what would it have cost and would industry have shared with that. Did you discuss that with them?

Mr. VAUGHAN. We had extensive discussions ranging over the last year with those citizens and companies that were interested in the MHD effort in this country. We did try to reach a viable program with that industry. By the time we put this budget together, we had not received any formal proposals from the community for cost sharing with the Federal Government. I want to point out that there had been extensive discussions with the industry and we certainly expected the possibility.

Mr. FUQUA. Had DOE offered them any proposal for cost-sharing?1

Mr. VAUGHAN. We had indicated that the best we felt we could do in future years, at considerable strain on the budget in our opinion, was the level of roughly $30 million and that that was an absolute max and we had to see something in private sector offers.

Let me be very candid with you, Mr. Chairman, about why MHD was one of those programs selected in the preparation of this budget in light of the severe fiscal restraints. MHD meets the criteria. It is indeed long range. It is generic and it is still high-risk R&D. It is the type activity that fits the program as we envisioned its proper role. However, it also is a technology that has at least another 10 years of concerted efforts on the part of Government and the private sector to bring it to any kind of operational demonstration.

When one is faced with the need to severely cut back Federal spending, and one wishes to maintain as broad a program as possible with as many options as possible, then one looks for the big ticket items to take out of there, even if they meet our established criteria. It is for those reasons alone that MHD has no operating funds proposed in the 1986 budget. We would hope to make those facilities available and we hope that the private sector can make appropriate use of those. I would point out that's well in excess of $100 million worth of property and equipment that could be made available from the Federal Government at several facilities, several laboratories, several magnets. We still have the magnet in Russia that we are still under some obligation to bring home as part of this program.

Mr. FUQUA. What about the fuel cells?

Mr. VAUGHAN. We believe, Mr. Chairman, that the phosphoric acid fuel cell has essentially passed through the phase of proof of concept and that it is a technology that does not need further Federal funding. It can pass on into commercial application without the assist of Federal funding.

Mr. FUQUA. We are also informed that the liquefaction program is ceasing at Wilsonville and La Porte before you even completed that acquisition program. Can you clarify that situation?

Mr. VAUGHAN. In our technical judgement, Mr. Chairman, both projects will have completed the proof of concept stage and passed through that portal this year. Further tests, while providing useful information, would only refine the process for specific conditions.

This is something, we believe, industry should and is capable of funding. In other words, the generic work will have been completed.

Mr. FUQUA. It was my understanding that they felt that 1 more year was needed to complete that project in Wilsonville.

Mr. VAUGHAN. We believe that the project can be successfully completed within the current year on technological grounds. Not all the bells, hoots, horns, and whistles will be on it, but the guts of the effort will be finished successfully in the current fiscal year.

Mr. FUQUA. Thank you. Mr. McCurdy.

Mr. MCCURDY. Thank you, Mr. Chairman. I ask the Chair's indulgence, I think I am going to read my statement because, after hearing the points that Mr. Vaughan made this morning in summary of his paper, I didn't hear anything mentioned about the area that I am interested in most, enhanced oil recovery. I hear a lot about coal, and I've heard that probably a dozen times in the paper, but I think before I ask my questions you ought to hear what I think on this issue.

My interest in the fossil energy budget lies primarily with petroleum research, more specifically, enhanced oil recovery research. Experts in my State of Oklahoma tell me that oil production in the lower 48 States has declined 25 percent in recent years. Most of the decline has been in key-producing States, including ones represented by members of this panel; New Mexico, Texas, Oklahoma, and Illinois are a few. In addition, employment in petroleum extraction dropped 13 percent in 1983 alone. I'm afraid that if this trend continues, many producing States will be out of the oil business. How do we offset a decline that robs our State treasuries of revenue, our citizens of their jobs, and the American public of its needed energy supply? The answer is, we go after oil that has been abandoned in known U.S. reservoirs. By some estimates, there is 300 billion barrels yet to be extracted from wells. Only enhanced oil recovery methods can reach this oil.

The Federal Government has a clear role in developing the technology to accomplish this. They may ask, are the oil companies interested in EOR research? Of course they are but they're not producing data for general use. Their information is too site specific. Are the oil companies producing oil from abandoned wells through EOR methods? Yes, but not fast enough, and only in a few isolated areas with favorable conditions.

It's cheaper to get energy these days in other ways. They can purchase or merge to gain new reserves. They can drill on Wall Street and have better results. They can also drill offshore or explore abroad. Unfortunately, our States don't have the same mobility. The best means of developing the technology is to boost our reserves and secure our energy independence and they lie with Federal EOR methods.

The sooner this research yields the models and data base needed, the sooner we can offset declining production and improve our damaged producing state economies. The public sector is greatly served by this kind of basic research. Long range EOR research done at the National Institute of Petroleum and Energy Research and in our country's universities. Dr. Charles Mankin of the Oklahoma Geological Survey was to testify on the benefits of EOR this morning, but could not accommodate the hearing date change to his schedule. I would refer members of this panel to his testimony for further information.

Mr. Vaughan, I wanted to make that statement and make it clear that there are some of us on this panel who believe that coal is important, that research is vital, and that we need to continue that effort, but that we don't want to overlook one of the most important areas of recovering vast reserves in known reservoirs throughout the South and West.

I see in the appendix to the statement that there is some effort there, but I'm not sure that's enough and I would like to ask you if you would please describe the role that universities play in EOR research. Is this year's budget sufficient enough to support their role, and do you see their role expanding in the years to come?

Mr. VAUGHAN. In answer to your question and your statement, let me say that I find really nothing in your statement that I take any umbrage with. I agree with your facts and figures, as I recall them anyway. Enhanced oil recovery is an important topic and the department is addressing it in this program. As a matter of fact, the fiscal 1986 budget is $1½ million—I'm sorry—1.5 percent higher than it was in the current fiscal year for enhanced oil recovery. I think we are addressing this concern. As your statement indicated, our principal focus is at generally—at the Bartlesville project office, and in conjunction with NIPER, the organization you mentioned. There is some small amount of funding through universities.

Our program in enhanced oil recovery is concentrated, as your statement indicated, in the data collection area. That is essentially what we're doing. We see no compelling need for the Federal Government in the oil business to deal with the equipment side of the equation and I did not interpret your statement to feel so either.

I believe the answer to your question is we are doing an adequate level. Obviously, one can always do more in any of these activities, but particularly in light of the extreme fiscal restraints we are operating under to increase a program is recognizing its importance.

Mr. MCCURDY. I appreciate the gentleman's comments and I would only cite one figure in conclusion for me and that is the proportion of the state tax revenues derived from petroleum production in 1982 figures; in Texas it is 26 percent, New Mexico, 28 percent; Louisiana, 31 percent; Oklahoma, 27 percent; Wyoming, 34 percent; and Alaska, 62 percent. There are a lot of States that are currently hurt very badly because of the recession and the decline in oil prices, and I think this is an area where production is down and the states are adversely affected.

I appreciate the gentleman's remarks. I would ask that they continue to work with us in the future on one of the most important areas of energy research.

Mr. FUQUA. Mr. Boucher.

Mr. BOUCHER. Thank you, Mr. Chairman. I have a number of questions that I intend to propound to Mr. Vaughan. I notice we have a call to the House. Would it we be appropriate to suggest that the subcommittee stand in recess pending this vote?

Mr. FUQUA. You can go ahead and ask your questions, if you like.

Mr. BOUCHER. Well, all right. I'll start now.

Mr. FUQUA. We've got 5 minutes.

Mr. BOUCHER. Thank you, Mr. Chairman. Mr. Vaughan, I was very pleased to note in your budget submittal that you are not recommending substantial reductions in a number of categories which I think are particularly helpful, primarily coal preparation, advanced combustion technology, and heat engines. In the past I've expressed my support for substantial funding in these areas and I was pleased to see that the Department is recommending essentially level funding in these areas for the upcoming fiscal year.

Let me propound a couple of questions with regard to some projects in which I have a particular interest. First of all, as I am sure you are aware, there are three stages at which sulfur can be removed from coal. First of all, prior to combustion through coal cleaning and appropriate washing processes, during combustion through processes such as fluidized bed, and following combustion through flue gas cleanup—flue gas treatment. Now generally speaking and recognizing coal's variabilities, how does the cost of removing sulfur at each of these three stages compare? Which is the most cost-effective?

Mr. VAUGHAN. That is a very difficult question to answer, Congressman Boucher. I, quite frankly, am not sure there is any hard definitive answer. Let me say, one of the things I am convinced of: the most cost-effective, in my experience, is not flue gas cleanup. In fact, in my judgement, it's the most costly approach to the problem.

Unfortunately, though, it deals with a reality and that is our existing capital stock of plant and equipment either in utilities or industries across this nation. We must deal with that reality. Flue gas cleanup still must be an active program in my judgment. I do believe, however, and we have an RFP out now on the street, that we need in flue gas desulfurization, particularly for utility application, significant cost reductions in the type and technique of equipment that is applied. That is what our RFP is designed to deal with. That is a calculated risk on our part because we must convince our colleagues at EPA that when they finally deal with the regulations for acid rain, that they will not impose the best available technology approach. If they do, we will have proceeded on the wrong path and our utilities, particularly in the Midwest and the industrial heartland of this country, will face very, very severe financial problems, and do considerable overkill in environmental protection.

Mr. BOUCHER. Let me say that I concur wholeheartedly in your statement that flue gas treatment is not the most cost-effective means of removing sulfur from coal and I think you would agree, that precombustion clean up is far more cost-effective than is postcombustion clean up, leaving aside for a moment the question of whether fluidized bed is a competitive process in terms of cost-effectiveness with preclean up technologies.

Mr. VAUGHAN. No question in my judgment, Mr. Boucher, that precombustion clean up is far preferable. One of the prime benefits of effort in precombustion clean up is the manufacturing of new fuels and the tailoring of the fuel to really meet the particular piece of equipment and its locality with respect to environmental needs. That can be much more carefully designed to the needs through clean up in advance than clean up on the tail end.

Moving over to the actual combustion process, fluidized bed combustion is only one of several promising technologies. That kind of technology, fluidized bed, is for new applications; it is not suitable for existing applications.

Mr. BOUCHER. Let me redirect the question here just a bit, if I may. Having established that precombustion clean up is cost-effective, certainly more so than flue gas treatment, let's take a look at the funding priorities that you're recommending for the upcoming fiscal year.

You may recall that last year Congress approved the clean coal technology reserve and essentially authorized $750 million for that purpose. That is directed squarely at the kind of concerns that you and I have been discussing; precombustion clean up. Now I understand that some 170 separate proposals have been submitted to the Department of Energy for funding under the clean coal technology reserve. I also understand that the Department is expressing some reluctance to fund any of these projects. I wonder if that's true? If it is, that concerns me greatly.

Mr. VAUGHAN. These projects—I will take some umbrage with you, Mr. Boucher—these projects have not been submitted for funding if they are responsive to the notice. The notice very clearly stated what Congress had done. It had created the authorization. It appropriated no funds. We felt that to be fair, both with respect to those who would be drafting informational proposals and to be fair to the taxpayer to be sure that we did not create liabilities on the part of the Federal Government, that we had to very carefully point that out in the notice, and we did. The notice, in fact, quotes from the statute and lays out the situation quite clearly.

Mr. BOUCHER. Mr. Vaughan, let me interrupt you just for a second. I fully am aware of the fact that Congress has not appropriated the first dollar. The $750 million does constitute an authorization. DOE is requested to submit a report in May, I believe, of this year which makes recommendations for funding of specific projects. I believe you have submitted to potential applicants a request for a submission of those projects. In turn, you will be submitting to Congress a report that recommends appropriations.

I understand that DOE is expressing some reluctance today to make that kind of favorable recommendation. Am I misled by that? I hope I am.

Mr. VAUGHAN. No, I don't think you're misled, but I would want to change some of your words. We are going to comply with the statute that you passed. We are going to review these proposals technically, and there are 50 technicians and scientists set aside and busily at work now reviewing those 170-plus proposals. We are going to very strictly follow what you commanded us to do in the statute for the preparation of this report. I do not recall that the statute requires us in any way to make funding recommendations. Having read that very carefully several times, I believe I am correctly informed on that point.

The administration, as it committed last fall in the budget process when this matter was arrived at, will keep its commitments.

That is, it will provide the means—and it has—for receiving such proposals. It will technically evaluate them individually and file a report with the Congress in the 10 categories required by the statute. I do not believe that we can lawfully under other statutes take those submissions and make them, in effect, proposals for funding. We and the administration cannot do that because we would have engaged, in effect, in the specifically unlawful conduct of solicited unsolicited proposals. We were unable, and it is unlawful for us, to solicit proposals for any activity for which we do not have funds in hand. That is why these are not proposals in the usual sense of the word; because there is not funding present.

We will, as always, be available to the Congress for capability statements' technical evaluation. But I would point out that they are discrete individual requests and that a properly drafted capability statement is not a comparative affair. It is a situation where this committee, or a member, has submitted to ask us to technically inform him or the committee about a particular proposal. If those requests are filed, then we will respond to them professionally and to the best of our ability. But we do not contemplate filing an amended budget or a set of funding recommendations.

Mr. BOUCHER. Let me be sure I understand your answer. You are saying that the Department will not make adverse recommendations with respect to appropriations from this reserve. Is that correct?

Mr. VAUGHAN. No, I don't think I said that because we may well receive some proposals that on technological merit alone, the Administration would find itself duty-bound to inform you that we thought they had inadequate technical merit or no technical merit. Anything that this Administration files with the Congress with respect to funding, will be consistent with the Administration's views about Federal spending and the problem of the deficit.

Mr. BOUCHER. I'm not sure that I quite understand your answer. I guess my problem is that I see this as an enormously promising area. Congress, I think, has agreed with that by making this $750 million authorization and has directed the Department to make some evaluations of proposals for funding that are submitted by potential applicants. Some 170 have been received by you to date. You are required to submit a report to Congress in May of this year which contains some recommendations, as I understand it. Now perhaps I'm wrong about your need to submit recommendations, but I was told that you were. Is that correct? Are you supposed to submit recommendations in May?

Mr. VAUGHAN. We certainly are, I believe, at liberty to submit any recommendations that the administration or Department thinks appropriate. I do not believe that we are required under the wording of this statute to amend the budget or make budget requests pursuant to this statute. In fact, until the funding is present—I realize we are off in a hyper-technical area now of procurement regulations—it is unlawful for us to advertise for proposals for projects for which we do not have the funding in hand. I'm not trying to be cute or coy with you; I believe these are serious issues.

Mr. **Boucher**. I'm sure you're not. What kinds of information will you be supplying to the Congress in this May report with respect to the 170 some odd proposals that you've received?

Mr. **Vaughan**. I think perhaps the best answer is, and I will read a line from a letter going back to Senator Byrd on this same subject: "After their analysis, a report to Congress on the potential usefulness of each emerging clean coal technology"—and I ad lib here; please note that's a technology, not a proposal or project. The statute enjoins us to look at 10 groupings of technologies; it does not direct us toward specific projects or proposals—"and the extent to which Federal incentives will accelerate the commercial availability of those technologies will be written."

The report is due to the Congress on May 1, 1985, and it is our intent to file the report on time.

Mr. **Boucher**. Would it be fair to summarize that statement by saying that you will not be making funding recommendations either positive or adverse?

Mr. **Vaughan**. That is correct. In this report, we would not make funding recommendations. In capability statements or specific questions you or your colleagues may direct, we would answer technically and generally we would tell you what the administration thinks about funding that particular item.

Mr. **Boucher**. That's fine. I appreciate that and I'll look forward to receiving a copy of that report.

Let me, if I may Mr. Chairman, pursue several additional questions. In DOE's budget request, you are listing several expected accomplishments for the 1985 fiscal year. One of those is development of the purged carbon process, which is a way to create superclean coal. There is industrial interest in this process; in fact, I understand that General Motors recently purchased some superclean coal created through the purged carbon process. Unfortunately, that purchase was made from Japan because the United States has not developed that process at the present time. There was funding contained, or at least a direction contained, in the appropriations bill last year for $1 million for the purged carbon process. I'm pleased to see that DOE is expecting that to be among its accomplishments for fiscal year 1985. What gives me concern, however, is that DOE has also submitted to the Appropriations Committee a list of requested deferrals for fiscal year 1985 into fiscal year 1986. One of those happens to be the purged carbon process.

How can you be expecting that to be an accomplishment for fiscal year 1985 when you're at the same time asking it to be deferred to fiscal year 1986? I see some inconsistencies in that.

Mr. **Vaughan**. We are proposing to defer some $983,000 of fiscal 1985 appropriations related to purged carbon. Our previous assessment of the purged carbon process indicated a number of technical and economical shortcomings in this process. The data we have received indicates that the process may remove significant quantities of ash, that is somewhere on the order of 95 percent, from certain coals along with pyritic sulfur. But the process has no mechanism for removing organic sulfur. Without a mechanism for removing organic sulfur, the process will not have the potential to remove 90 percent total sulfur. Therefore, the process has a relatively low market value, since scrubbers would still be needed where new source performance standards apply.

Other chemical cleaning processes are under development which have demonstrated, to date at laboratory scale, the ability to remove 90 percent of the total sulfur and 95 percent of the ash from a variety of coals with preliminary cost estimates similar to those projected for purged carbon. Further, there are some physical cleaning processes under development with the potential to remove up to 95 percent of the ash and pyritic sulfur, which can do it at much lower process costs than purged carbon.

Mr. BOUCHER. Mr. Vaughan, you're citing the reasons why DOE might be requesting a deferral but I don't think that answers the question of how you can list this as an expected accomplishment for the current fiscal year simultaneously with requesting a deferral for the next fiscal year. Which really is your intention? Is it to complete the project this year or to defer it to next year?

Mr. VAUGHAN. I'm sorry, I didn't quite understand your question. This fiscal 1986 budget was written, obviously, based upon 1985 appropriations and our earlier review indicated promise in this area. It is data that came in subsequently to the drafting and filing that causes me to make the statements I just made and to raise technical doubt. Again, if you are in extraordinary budget constraint times, if you pick up negatives on a particular process or project and they look to be serious, then that becomes a candidate for deferral or delay to some later time. That's the explanation for purged carbon.

Mr. BOUCHER. That's a reasonable explanation. I would assume that, in the event, Congress does not approve your requested deferrals, that you would comply with Congress' earlier direction and fund that process in the current fiscal year.

Mr. VAUGHAN. Absolutely, Congressman. If the Congress does not approve our deferrals, we will execute those programs to the best of our ability.

Mr. BOUCHER. Mr. Chairman, I have one further question. I don't think this will consume much time.

Mr. Vaughan, I understand that one of the coal companies in my district, United Coal Co., has recently concluded a very successful test of the use of liquid coal which is the gases condensed from the burning of coal and the condensation of volatiles reinserted with the coal char in a Cummins diesel engine. They are, for the first time, burning this form of liquid coal in the place of diesel engine oil. I find that to be interesting, and promising, and I wonder if, first of all, DOE is aware of that accomplishment and, second, what plans you have through your heat engine funding to advance that kind of research in the future.

Mr. VAUGHAN. We are aware of United Coal Co.'s activities. They are one of the very active coal companies in research and development and one that I find very comfortable to applaud for their activities since the vast majority of their projects are self-thought-out and self-funded. Of course, they reap the benefits from them and they are highly successful. The whole concept of the new fuel form liquid coal is very promising looking and I believe it is the best news in the coal business existent today. That is a breakthrough and there is already much competition both here among

U.S. companies in this area and internationally with this new fuel form. I see great promise for it.

In our heat engines program, through our AR and TD efforts, the crosscutting fuel efforts, we will try and make sure we do take into account in engine design and research, the fuel itself. We will make allowance for this fuel form. We are quite interested in those efforts. There are a number of places where these efforts can bear fruit; boiler fuels, turbines, diesel engines, all look quite promising as far as I can see at this time.

Mr. **Boucher**. Am I correct in interpreting your comments to mean that DOE would welcome funding proposals with respect to the use of liquid coal in diesel engines?

Mr. **Vaughan**. Yes; I think as a general proposition, Congressman, we would welcome funding proposals, although I would caution that this area seems to be proceeding quite satisfactorily on its own. I certainly would enjoin companies to think very carefully about the necessary entanglement of patent rights, et cetera, that will follow at this stage if they ask for public funding.

Mr. **Boucher**. Well, patent considerations aside, I suppose a company would make that determination before it submitted a proposal for funding. Is it fair to conclude that in your heat engines category, your request for fiscal year 1986 contains funds that could properly be applied toward this purpose?

Mr. **Vaughan**. I believe we had a RFP from our Morgantown Energy Technology Center, Congressman, that I believe closed during the last day or so that directly dealt with this subject. So, I think the short answer to your question is yes.

Mr. **Boucher**. Thank you very much, Mr. Vaughan, and thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you. Mr. Walgren.

Mr. **Walgren**. Thank you, Mr. Chairman. Mr. Secretary, in the budget request comparing the 1986 request with the 1985 estimates, if you go through there one of the things that stands out as the largest increase is in what amounts to a policy and management cost under program direction and management support. If you take out the capital equipment and the construction and you just look at headquarters program direction and ETC program direction, that's up about 16 percent from 1985 to 1986. It seems a little unusual to see what our relatively upper level management cost, as I understand it, rising substantially in pure dollars, let alone percentages, when the implementation budgets are being reduced. Why is that the case and what does it reflect?

Mr. **Vaughan**. I'm glad you asked that question, Congressman. What you're seeing there is a regrouping of funding from past practices. In the past, this program, fossil energy like many other programs, assessed or taxed the various implementation programs for the overhead and planning and management activity to carry the entire effort. Congress has been critical of that way of accounting, and so we reordered our books in the fossil energy program and placed all of that in identifiable category as a line-item budget.

Mr. **Walgren**. So, what you're saying is that if we went back and restated the fiscal year 1985 estimate column, we would find different items in the headquarters program directions that are reflected in the fiscal year 1986 request? In that sense, those two columns would be apples and oranges.

Mr. VAUGHAN. I believe yes. I also believe if you would go back and take our 1985 budget request and reorder it on the same basis that we have it shown in the 1986, you would find, in that category, less than $1,000 difference—less than $100,000 difference.

Mr. WALGREN. I certainly appreciate that answer. I do want to emphasize the attention that should be paid to those kinds of distributions because if it is such that the management direction per se is not being cut and the actual meat that we're delivering is being cut, I think that would be a subject of real criticism.

Let me also ask, does this mean that the line programs at that point would not carry the cost for management and administration as such? When you say that you're now no longer taxing line programs for management and administrative costs, would that mean that throughout this whole budget you're going to be seeing at that point a change in the values but not a change in the effort?

Mr. VAUGHAN. That is correct, yes sir.

Mr. WALGREN. I will have to try and factor that in. Let me ask in the limited time that I have, in Homer City you have entered into, with the Electric Power Research Institute, an effort of coal cleaning. Can I just ask at the start, how clean do we expect the runs to be up there at Homer City? Are they going to be really clean compared to a fluidized bed process? I'm just trying to get a measure of the potential here. I don't want a long detailed answer.

Mr. VAUGHAN. We're talking in the order of 90 percent pyritic sulfur removal. In the pyritic sulfur game, that's pretty good.

Mr. WALGREN. And the proposals, as I understand it, are out of the Department and being responded to by the private sector and you're receiving proposals back as to what kind of projects to conduct there. Is that where we are?

Mr. VAUGHAN. Yes; they're on the street now to be received not before April 10 this year.

Mr. WALGREN. How much money is budgeted for that effort as a whole?

Mr. VAUGHAN. Essentially, $4 million over 2 years.

Mr. WALGREN. Is this—could you do more than that if you received project proposals that had real promise—would you be interested as a Department in doing more than $4 million in the near term?

Mr. VAUGHAN. The simple answer to your question is until you see the proposals and evaluate them technically, you really just don't know. That's the simple answer. I don't know what we'll get so I can't answer that question.

Mr. WALGREN. Mr. Chairman, I heard the bell, but if I could be permitted one additional question with the indulgence of the other members. We're apparently going to conduct some coal-cleaning projects in that Homer City plant. Do you have money in the budget to then burn the coal that's clean so that we are actually demonstrating to industry that we have a product that they can then pick up and move directly on? I would hate to think that we're just cleaning the coal and handing out an empty shell that might be of no use because its heat value is diminished or the like.

Do you have money in the budget to demonstrate the burning in a useful fashion to industry after you've cleaned that coal?

Mr. **Vaughan**. We do not have in the budget specific funds to pay for the coal for the burning. However, this is a joint activity with the Electric Power Research Institute and their portion of the—among other things, one of their duties in this activity is to do the burning of this coal. The answer to your question is that our funds are not being used for that specific purpose but the project work at Homer City in conjunction with the EPRI will accomplish the entire effort.

Mr. **Walgren**. We have a commitment from the private portion of that program to give us that demonstration?

Mr. **Vaughan**. Yes.

Mr. **Walgren**. Thank you, Mr. Chairman. I'll submit the other questions I have.

Mr. **Fuqua**. Thank you. Ms. Schneider.

Ms. **Schneider**. Thank you. My colleagues who preceded me asked a number of very specific questions on a variety of projects. I'm not going to ask you about specific projects but rather about acid rain. In your testimony, you had indicated that your agency was anxiously moving ahead to remove acid-rain-causing pollutants. My question to you is, along what route—what is the path that you are taking to remove these acid-rain-causing pollutants? Are you not interested in developing technologies that don't even create the acid rain in the first place? In other words, what kind of philosophy do you have toward preventive measures?

Mr. **Vaughan**. We are taking the broadest possible approach to dealing with pollutants from coal and specifically acid rain precursors—that is, the sulfur and nitrogen oxides. We have a considerable amount of activity in the precleaning of these coals and we are trying to address both parts of the sulfur problem in coal; specifically, the pyritic sulfur, which is the easy sulfur to get out, and the more difficult chemically bound sulfur. We have considerable effort in those areas of precleaning. We also, and I'm going to jump the combustion process for a moment, have efforts in the post combustion cleanup and while that is not the most efficient way to deal with the problem, it is facing the reality that the Nation has considerable capital stock invested in plant and equipment that is operating today and still has useful lives that are far from running out. Therefore, we need retrofit capabilities. In addition, we are dealing with the combustion process itself. I think in a most ideal world, that would be the place all of us would like for all the nice answers to come out. I would point out that there is great promise in this research.

Ms. **Schneider**. Could you be a little more specific?

Mr. **Vaughan**. There is the fluidized bed boiler. It is quite successful in this area. Heat engines that we have in the program, that is, diesel engines powered with coal or new coal water fuels and turbines—all offer possibilities in this area.

Ms. **Schneider**. That leads me into my next question, since you did mention fluidized beds. You're asking for an additional $2.8 million for 1986 for pressurized fluidized bed combustion in a cost-share program with industry. I'm just wondering, since the purpose of this funding is to develop a second-generation fluidized bed, what's the status of the first generation? Why haven't we seen more fluidized bed first generation out there being commercially utilized?

Mr. **Vaughan**. We have and we are seeing. There are over 100 applications existent in this country today——

Ms. **Schneider**. That's not many at all. When you consider the number of areas that are interested in setting up small facilities for generating additional electricity——

Mr. **Vaughan**. I think considering that's new equipment, that it is considerable because unless one contemplates junking existing capital stock and, say, utility electric generation equipment, and adopting instantly the new technology before the useful lives have run out, this is good progress.

If one adopts this latter approach, which I certainly don't recommend, because I don't believe that we, as a nation, can afford it. I believe we must make an orderly transition and thus, our efforts on the tail end to provide the retrofit option for the capital stock that we currently have.

Ms. **Schneider**. It's interesting that you should mention we may not be able to afford it, because when you do the entire fuel cycle cost analysis, it oftentimes seems to be more cost-efficient to scrap, particularly in the industrialized Northeast-Midwest part of the region, some of those old facilities and to build new ones. What you're actually saving are not only the original capital costs, but throughout the whole cycle, the cost of treating some of the fuel sources, the cost of cleanup from acid rain or fly ash or whatever other pollutants might occur through the process. I just wondered if your shop is doing any kind of cost analysis of the value of some of these new technologies? It seems to me if you were, we would see commercialization happening much more rapidly. The stalling on the part of retrofitting might be put aside.

Mr. **Vaughan**. We do cost analysis and, most assuredly, the private sector does. We do not see in this administration that our role is one of forcing or causing to happen commercialization. What we see as our role is to deal with generic, long-range, high-risk research; answer the technical problems that the private sector is unwilling or incapable of answering for itself; and then leaving to the private sector the choices as to what timeframes and on what basis things will move into commercial application. The Government experience, in looking over the past number of years, is that the Government has been singularly unsuccessful and is, in our judgment, singularly ill-equipped to make these kinds of commercial judgments for the private sector. It is for that reason that our program is consciously up in the first part of the equation that is dealing with technical questions, our purpose being to offer a technical array that the private sector can decide and make the competitive calculations as to when and how to move it into application.

Ms. **Schneider**. Thank you. My time is up. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you. Mr. Traficant.

Mr. **Traficant**. Thank you, Mr. Chairman. Mr. Vaughan, there's been quite a bit of testimony relative to clean coal technology reserve and perhaps I may have missed some. You know, Ohio is being blamed as the culprit for much of this high sulfur emission and I believe Canada has been complaining quite a bit about that high sulfur coal from Ohio and the emissions therefrom. I know that the Ohio Coal Development Office submitted several proposals for review to the Department of Energy relative to that problem that we have there. If you could, and hoping that I didn't miss some of your previous testimony that may have addressed this, what is the status of this particular project and those projects that have been submitted by the Ohio Coal Development Office? What particular areas of research and development might the Department of Energy be looking into to support to help Ohio with that problem and to perhaps open up the salability of its high sulfur coal to the markets?

Mr. **Vaughan**. Let me try to answer that question on two planes. First the plane of the $750 million clean coal technology authorization that, pursuant to which, these particular ideas were submitted. That activity is in progress now. We have received some 170 plus responses from the private sector and, quite candidly, from some State and maybe even some local governments in response to that notice. We are, under the statute, required to file with the Congress a report that will deal with these technological ideas and that report is due to be filed May 1. It is in the preparation of that report that these proposals or responses are being technically evaluated. We intend to file that report with the Congress on time. I think, frankly, at this point—I do not know specifically about the development office of Ohio proposals, other than the fact I noticed that several were received and were in the list. I think it would be, even if I knew, inappropriate in an open public hearing to describe their relative merits. I don't think we know yet.

With respect to the broader question of Ohio's coals, Ohio is blessed along with a number of States in that general region with a fair amount of coal as a natural resource and Ohio burns and utilizes a lot of that resource. Unfortunately, much of that coal has an unwanted ingredient that comes with it, the sulfur; and our program in coal is specifically designed to deal with acid rain precursors. I believe it is a broad base aggressive program trying to deal with this general problem of acid rain precursors on the broadest possible base so that we can hopefully arrive at an array of answers as rapidly as possible and technology will permit us.

Unfortunately, the one thing you can't do very well is force technology. You can make available the environment in which study can go on, but no amount of funding really insures that you have success. One of the ways to broaden the prospects of success is to approach the problem generically and broadly and I believe we're doing that.

Mr. **Traficant**. I would like to add that the coal reserves in the State of Ohio are very plentiful and even though it may not be appropriate here to broach these types of concerns, I think the country should have great concerns about the reserves of coal in the State of Ohio and the fact that perhaps more can be done with them. I would hope that your office would notify me and my staff so that we can follow through very carefully what might be developing relative to Ohio coal.

We are very concerned along those lines and the State government is as well. It's of great concern to us there.

Mr. **Vaughan**. We'd be happy to.

Mr. **Traficant**. Yes. One other question just quickly, Mr. Chairman. On the Eastern oil shale, I don't know if that's also been addressed, but from the information that's been made available to me, the actual magnitude of the oil recoverable from known sources of Eastern oil shales alone could be as high as 1,000 billion barrels, enough energy to supply the entire United States with gas and oil for more than 100 years at current levels of consumption and more than eight times the total of recoverable U.S. oil reserves. My question is what is the Department of Energy doing in the area of Eastern oil shale, especially in the light of this tremendous potential this energy resource may hold for the future in perhaps reducing our dependence on foreign entities for energy.

Mr. **Vaughan**. We have a program dealing with oil shales. Oil shales, as you know, exist both in the west and in the eastern portions of the country. Unfortunately, their problems and characteristics are different. We have activity that is designed to deal with both resources. Our 1986 proposed effort in that area is some $3 million worth of funding for Eastern oil shales.

Mr. **Traficant**. Do you believe that's an appropriate amount at this stage? I'm not familiar with last year's—I haven't been into that. What is the priority placed upon that recovery in both the west and the east?

Mr. **Vaughan**. The priority placed on oil shale today, east and west, is much lower and, frankly, the reason is that we have technology, particularly with respect to western shales, that can produce oil. Unfortunately, it produces oil at three to four times the market value of oil today. In light of that rather significant market difference, we have not felt that we should have vast quantities of funding in those areas. Obviously, one can always disagree with that kind of judgment. However, we believe that as we see it we should deal with long range, high risk, generic problems. That's what we are addressing.

The second part of any technological march beyond the first part is the technical question, essentially, and the second part is more economic as you scale up, demonstrate, and commercialize the technology. That area that is the second step facing three to four times out of phase with market value, has fallen on hard times. I think that's just reality. In light of that, we believe we have an adequate program but I don't think it would be fair to characterize it as the front burner activity in fossil R&D.

Mr. **Traficant**. Thank you, Mr. Vaughan. Mr. Chairman, thank you.

Mr. **Fuqua**. Mr. Fawell.

Mr. **Fawell**. I apologize, Mr. Chairman; I missed some of this testimony. The overall fossil energy program has been reduced by about $104 million or 34 percent and I am somewhat concerned, parochially speaking, in reference to its effect upon Argonne National Laboratory, which happens to be in my district, as you may have guessed, simply because it's been asked by DOE to take something like a $40 million cut this year overall, from $191 million down to $151 million, which is a very severe cut. Argonne also conducts many research activities which are funded under the fossil energy program; for instance the MHD related R&D is performed, and efforts are carried out in the coal gasification field. Consequently, I have some concern here as to more cuts that could—the cuts we are facing now challenge the viability of the institution. Could you please provide me with detailed information on what Argonne activities would be affected by Department's budget request and to what extent? Please include funding cutbacks by program area, and the affected manpower reductions this would entail. Again, I ask this specifically because of the tremendous impact which is being felt in the Argonne National Lab.

Mr. VAUGHAN. I would be more than happy to provide that analysis for the record by program item.

[The information follows:]

ARGONNE NATIONAL LAB FY 1985 AND FY 1986 FUNDING

The enclosed table reflects the FY 1985 and FY 1986 Fossil Energy R&D allocations for Argonne National Laboratory and the changes for each program area.

FOSSIL ENERGY R&D ANL FUNDING CHANGES: FISCAL YEAR 1985 TO FISCAL YEAR 1986

[In thousands of dollars]

Program area	Fiscal year— 1985	Fiscal year— 1986	Change
Control technology and coal preparation	$1,574	$445	−$1,129
Advanced research and technology development	3,158	2,681	−477
Coal liquefaction	200	0	−200
Combustion systems	143	250	+107
Fuel cells	650	900	+250
Heat engines	170	0	−170
Underground coal gasification	0	0	0
Magnetohydrodynamics	482	0	−482
Surface coal gasification	1,250	663	−587
Total coal	7,627	4,939	−2,688
Unconventional gas recovery	0	0	0
Advanced process technology	0	0	0
Enhanced oil recovery	0	0	0
Oil shale	0	0	0
Total petroleum	0	0	0
Capital equipment	35	0	−35
Total fossil energy R&D	7,662	4,939	−2,723

Mr. FAWELL. It might be better if you would just send that, obviously. Also, in light of the objective of the Department to increase the contribution of coal by improvements in environmental, technical, and economic performance, why are these reductions forthcoming? I realize that you said budget constraints in your written statement, but is it not so that there are priorities where there is shifting of funds in R&D to other areas?

Mr. VAUGHAN. I think that is precisely what we have done. As you build any budget you inherently set some priorities. When you have to do some budget cutting, the priority game becomes—there are two ways you can approach budget cutting. You can do it across the board, which in my judgement is kind of a mindless way to go about it where one does not make any value judgments or technical judgments about what one is about, one just simply spreads the misery. That is, it seems to me, precisely the wrong thing to do with research and development activity because there are levels at which, if you do not provide this level of funding, providing some lesser level is essentially a waste of time, money, and effort. You need to set priorities.

[The information follows:]

PRIVATE SECTOR FUNDING FOR FOSSIL ENERGY R&D

Getting a reliable estimate of private sector expenditures on fossil energy research and development (R&D) is difficult because many companies consider such information confidential. Furthermore, different estimates are difficult to compare due to differences in definitions of R&D, company accounting procedures, etc. However, the National Science Foundation (NSF) annual survey appears to represent the most comprehensive and carefully designed effort to gather such information. Industry results are available through 1983, which is shown below and indicate a steady rise in fossil energy R&D.

Fossil energy industrial R&D expenditures

	Million
1977	$644
1978	678
1979	788
1980	993
1981	1,257
1982	1,361
1983	1,465

NSF considers R&D for this survey as "basic and applied research in the sciences and engineering and the designing and development of prototypes and processes."

Mr. **FAWELL.** I want to make reference to some testimony that's coming after yours and perhaps this is a bit premature. In David O. Webb's testimony, I noted last night, while reading his statement, that a dramatic decline in energy R&D becomes very evident in his analysis of energy R&D in general, and he brings out that there's been quite a tremendous priority decision apparently for R&D to go to defense and he cites the difference between figures of fiscal year 1981 and fiscal year 1986. In fiscal year 1981, general energy R&D was about $6 billion or 60 percent, and defense was at about $4.4 billion. Defense, now, according to his figures, is up to $8 billion and energy R&D in general is about down to $2.3 billion. Is this the priority which is causing your programs in fossil energy to suffer, which, of course, affects environment and so many other areas of great consequence.

Mr. **VAUGHAN.** In my judgment, the answer to that is no. The type of differential is twofold. One is a redefinition of an appropriate role by this administration for Government R&D in energy-related activities. That was a very conscious effort and it had nothing to do with defense funding, no nexus whatsoever. It was a definition of a role that, as we saw it, we had no business competing with the private sector or in essentially the commercialization demonstration decisions which are necessary in the march of any technology.

Mr. **FAWELL.** Excuse me, I think my time may be up, but if I could propound just one other question. Are you saying that this would have occurred anyway, regardless of the float toward defense R&D?

Mr. **Vaughan**. In our view of what a proper role for Government in fossil R&D, yes I think these kinds of changes would have occurred. With respect to—in this particular budget cycle we are talking about, where we have made some even tougher priority decisions, here we have a deficit situation and I think that has a predominant effect. It is a major factor that we had to consider across the board in Federal spending for everything. Clearly there were some priorities made by the President about the value defense spending and, while I didn't make those decisions, I certainly support them.

Mr. **Fuqua**. Thank you. Mr. Packard.

Mr. **Packard**. Mr. Chairman, thank you. I am aware of the time constraints and I'll try to be very brief. You've been hammered pretty heavy this morning on the coal research and I'll hammer you just a little bit further on it.

Certainly we're all aware of the deficiencies of energy in this country and reliance on outside sources. Coal, being of significant surplus reserves in this country, would appear to me to be an area we would look toward for solving some of our energy shortfalls in the future. Therefore, I've been a supporter of coal research. I notice in your budget, the last sheet of your written proposal of your budget analysis, that under the budget authority between 1985 and 1986 for coal, there's a reduction of over 40 percent from 1985 to 1986 and a budget outlay reduction of about 23 percent. Those are significant reductions. I'm a supporter of reducing deficits, but I recognize that this may be a shifting of priorities.

Do we see an increase in the private sector's commitment toward coal research that offsets some of this decrease in the Government commitment to it or are we seeing an overall decrease in commitment to coal research? In visiting many of the experimental sites in California, I'm finding that coal gasification and other coal opportunities are far greater in terms of cost benefit ratios than many of the other research programs. I'm wondering if, in fact, we are decreasing our overall commitment to coal research.

Mr. **Vaughan**. As a nation, I think we are increasing our effort. I find it as one of my duties to be fairly familiar with what's going on in fossil R&D and particularly in coal, and I find that a number of private companies are either beginning to be interested in starting activities in coal R&D or they're stepping them up.

I visited the coal research laboratories of a major coal company in this country within the past year. Five or six years ago, those laboratories were funded over 90 percent with federally sponsored projects. Today those activities are funded essentially with the company's own money. I think that's an encouraging and great development. I am aware of another coal company's laboratory that is essentially brand new. They are less than 5 years old from ground up. That's a fairly new company. What I think we're seeing is a great deal of activity and growth.

Mr. **Packard**. It might be helpful if you would provide for us, if it's available to you, a general overall commitment from both the private and the public sector to coal research that would allow us to be convinced that there is not a decrease overall in coal research for the country itself.

Mr. **Vaughan.** I will provide you, Congressman, those things that I am aware of. I will point out that one should not view that as a definitive analysis since a number of companies do not make available their funding effort and I also do not particularly desire to engage in a mandatory report to the Government effort.

Mr. **Packard.** I would not seek that at all. I'm simply seeking—I see acid rain associated with coal research and future reserves of coal being utilized in this country to a greater degree than they are. I think it—I would just like to know if our commitment overall is remaining stable or decreasing or increasing.

Mr. **Vaughan.** Let me see what I can do in response to that.

Mr. **Fuqua.** Thank you very much, Mr. Packard. Bill, I think you can see from the interest this morning the sincere and positive concern that we have about fossil fuel. We thank you for being here and there may be some other questions in writing that may be submitted to you for response and we would appreciate that.

Mr. **Vaughan.** Thank you very much, Mr. Chairman. It's always a pleasure to be here.

Mr. **Fuqua.** Thank you very much. Our next group of witnesses will be Mr. Michael Baly, vice president of government relations, American Gas Association; Mr. David Webb, senior vice president, Gas Research Institute; and, Mr. Gene Mannella, deputy director, Washington office, Electric Power Research Institute.

Mr. Baly, we will begin with you and we will make your prepared statement a part of the record. You wish to summarize, as long as the summary takes less time than reading the full statement.

STATEMENT OF MICHAEL BALY, VICE PRESIDENT, GOVERNMENT RELATIONS, AMERICAN GAS ASSOCIATION

Mr. **Baly.** Mr. Chairman and members of the subcommittee.

The American Gas Association is a national trade association consisting of nearly 300 natural gas utility and transmission companies serving more than 160 million consumers in all 50 States. With me is Bernie Liebler, our manager of energy research, an engineer on loan to AGA from Brooklyn Union Gas Co. I am pleased to present AGA's statement in support of an authorization of $200 million for all DOE natural gas related R&D in fiscal year 1986. We believe that this funding will ensure adequate long-term supplies of natural gas and efficient use of those supplies.

The DOE was created in 1977 to coordinate national energy policy. In the enabling statute, Congress mandated that DOE was to "carry out the planning, coordination, support, and management for a balanced and comprehensive energy research and development program," including programs for "optimal development of the various forms of energy production and conservation." The DOE was also required to administer certain nuclear weapons research functions. Consistent with its congressional mandate, the DOE—by fiscal year 1980, was spending approximately $3.4 billion on defense-related weapons research and $5.9 billion on energy research.

Since 1980, the DOE has shifted its focus away from energy research and toward defense-related research. Thus, for fiscal year

1986, the DOE is requesting $7.3 billion for defense activities and only $2.1 billion for energy research. The DOE has become, in essence, an arm of the Department of Defense, funding less than 40 percent of the energy research that it funded in fiscal year 1980, while more than doubling its defense-related funding. If the DOE is to be the true focal point for national energy policy, it must concentrate more of its efforts on conducting serious energy research. We therefore call upon Congress to move toward restoring energy research funding to the priority status originally envisioned in the DOE Organization Act.

Geosciences stand as the most likely fields to produce major improvements in this country's energy supplies over the next several decades. Geoscience can open the door to tremendous quantities of heretofore unattainable gas and oil resources. Unfortunately, the DOE has chosen to ignore this potential, a highly inappropriate posture for the organization created to be the centerpiece of national energy policy.

We strongly suggest that Congress redirect the DOE's research activities and budget to reflect more accurately the Department's objectives and our Nation's needs. To this end, we recommend redirection of funds within the General Sciences and Basic Energy Sciences area. This redirection is intended to address the geosciences and resolve the research problems related to recovery of natural gas from deep sources, methane hydrates, and geopressured zones. It is also intended to address the materials research needs related to these technologies.

If the DOE were to address properly the geosciences, the recoverable resource base for natural gas would expand substantially. The Potential Gas Committee, the industry group that evaluates gas resources, has estimated that—with foreseeable technology and economics—the United States has approximately 1,078 Tcf or about 60 years—at today's consumption rates—of gas supplies from conventional sources. However, some experts contend that the total gas resource in place—that is, the conventional gas resources plus much more extensive unconventional resources—exceeds 100,000 Tcf. Although it is tempting to conceive of the Nation's gas resources as a fixed and stable quantity, history has shown that technological achievements by the gas industry, like improvements in techniques for drilling for gas in deep, offshore waters, have resulted in significant increases in the recoverable gas resource base. The current estimate of about 60 years of gas supplies could be doubled or tripled if future technological achievements were to enable the recovery of just 1 or 2 percent of the estimated total gas resource in place. The DOE, as the focal point of national energy policy, must take the lead in the attempt to achieve future technological successes by assuring adequate funding for these technologies.

The DOE has also strayed from its statutory mandate to promote energy conservation research and, in doing so, has neglected research of new technologies designed to use natural gas and other fossil fuels more efficiently. Thus, in redirecting its research priorities, the DOE must also focus more attention on research into new technologies that promote the efficient use of fossil fuels.

There are several reasons why the DOE should concentrate more of its efforts on natural gas utilization technologies. First, natural gas is more attractive environmentally than other fossil fuels, because gas combustion products contain almost no sulfur or particulate matter. Second, because a large potential gas resource base is located in the United States, development of new gas utilization technologies would displace some of the crude oil imported from the tumultuous Middle East and reduce the Nation's balance of trade deficit. Third, there are several new gas utilization technologies which offer greater fuel efficiencies and environmental benefits than are currently possible. In particular, there is tremendous potential for technological advancement in the area of electricity generation. Gas technologies, such as cogeneration, fuel cells, select use of gas, and combined cycle gas turbines, offer the potential for electricity generation which uses less primary energy, and lawyers capital costs, electricity prices, and emissions. The development of new, more efficient gas utilization technologies would help the DOE return to its original mandate of promoting energy conservation research.

I emphasize that what we request is a redirection of funds within the DOE R&D budget. We are not asking the DOE's overall R&D funding be increased during this critical time of budget constraints. We believe that this redirection of funds will improve the Nation's energy picture and strengthen the U.S. economy. Regarding our specific funding recommendations for fiscal year 1986, AGA's requests parallel the Gas Research Institute.

Highlighting the $16 million on geopressured methane, experts believe that over 100,000 tons/cubic feet of gas exists in the geopressured zones underneath Texas and Louisiana coasts. Unfortunately, DOE has concentrated its research in the geopressured zones on producing electricity from the inefficient low-grade heat in the reservoir brines. DOE should place more emphasis on developing novel approaches for recovering the gas in the geopressured zones, not the steam.

Surface coal gasification funds of $40.5 million will enable testing of utilizing caking coals in the East. Although you may have another hearing in the future, Mr. Chairman, on conservation, the $40 million for conservation research would enable advanced gas turbine development and the select use of gas with coal and other fuels which Alex Greene of the University of Florida, is advancing. The past Administrator of EPA, Mr. Ruckelshaus, cites the select use of gas with coal and other fuels as the way Japan has made a breakthrough in its environmental policy goals.

We would like to thank Congressman Glickman and others for the leadership and support that they have provided in the compressed natural gas vehicle development. We would like to see research there in terms of reducing carbon monoxide levels in some major cities.

We appreciate this important subcommittee giving us the opportunity to present the gas industry's views on gas R&D. We sincerely appreciate the support that you, Mr. Chairman, and your subcommittee, Bill Harvey, have given the gas industry in the past and we look forward to working closely with you this year. Thank you.

[The prepared statement of Mr. Baly follows:]

TESTIMONY OF
MICHAEL BALY III
VICE PRESIDENT, GOVERNMENT RELATIONS
AMERICAN GAS ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
ON THE DEPARTMENT OF ENERGY FY 1986 RESEARCH
AND DEVELOPMENT BUDGET
MARCH 6, 1985

Mr. Chairman and Members of the Subcommittee.

The American Gas Association (A.G.A.), whose members consist of nearly 300 natural gas distribution and transmission companies serving more than 160 million consumers in all 50 States, is pleased to present this statement in support of gas-related research and development (R&D) conducted or sponsored by the Department of Energy (DOE). A.G.A. recommends an authorization of $200 million for all DOE natural gas-related R&D in FY 1986. This level of funding is critical to energy resource development and utilization in general and to natural gas resource development and utilization in particular.

NEED FOR REDIRECTION IN FEDERAL ENERGY RESEARCH PRIORITIES

The DOE was created in 1977 to coordinate national energy policy.[1] In the enabling statute, Congress mandated that DOE was to "carry out the planning, coordination, support and management for a balanced and comprehensive energy research and development program," including programs for "optimal development of the various forms of energy production and conservation."[2] The DOE was also required to administer certain nuclear weapons research functions.[3] Consistent with its Congressional mandate, the DOE -- by FY 1980 -- was spending approximately $3.4 billion on defense-related weapons research and $5.9 billion on energy research.

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[1] Department of Energy Organization Act, section 102, 42 U.S.C. section 7112 (1977).

Since 1980, the DOE has shifted its focus away from energy research and toward defense-related research. Thus, for FY 1986, the DOE is requesting $7.3 billion for defense activities and only $2.1 billion for energy research. The DOE has become, in essence, an arm of the Department of Defense, funding less than 40 percent of the energy research that it funded in FY 1980, while more than doubling its defense-related funding. If the DOE is to be the true focal point for national energy policy, it must concentrate more of its efforts on conducting serious energy research. We therefore call upon Congress to move toward restoring energy research funding to the priority status originally envisioned in the DOE Organization Act.

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[2] 42 U.S.C. section 7112 (5).

[3] 42 U.S.C. section 7112 (18).

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SPECIFIC FUNDING RECOMMENDATIONS

UNCONVENTIONAL NATURAL GAS: $35 Million

Unconventional resources, such as tight sands and Devonian shales, contain extensive amounts of gas. A.G.A. has estimated that vigorous financial support of R&D programs to develop these resources could produce up to 3.0 Tcf of gas by the year 2000, while current technology would produce approximately 0.3 Tcf by that year. The Gas Research Institute (GRI) field test program also indicates that research and development in the unconventional gas area will result in significantly increased supplies.

Despite the promising potential of unconventional natural gas resources, the DOE's research efforts in this area have been systematically eroded over the past few years. Funding for DOE's unconventional gas program has decreased from $35 million in FY 1981 to $10.2 million in FY 1985. Furthermore, full-time DOE staff involved in this research has been slashed from 25 persons to 9 persons over the last 3 fiscal years. Because of the significant potential of unconventional gas resources, the DOE must make a greater effort to accelerate the development of these resources instead of slowing down this development.

To attain commercial viability for increased production from unconventional gas resources, more research must be conducted to develop advanced stimulation techniques to fracture tight rock formations that restrict gas flow. Current fracturing techniques induce only shallow fractures of a few hundred feet. Field testing must be conducted to refine techniques for inducing deep fractures of several thousand feet. Such techniques include foam, cryogenic, hydraulic, chemical explosive, and high energy gas fracturing. In addition, research information must be collected from field testing to establish a technological database for stimulation modelling, economic modelling and other analytical purposes.

GEOPRESSURED METHANE: $16 Million

Geopressured methane is found in either a free state or dissolved in water and trapped in sedimentary rock at higher-than-normal pressures. One of the largest geopressured areas underlies a portion of the Texas and Louisiana Gulf Coast. Estimates of the total resource in-place range up to 100,000 Tcf; however, estimates of the amounts of gas that might ultimately be recovered range between 25 and 1,200 Tcf. Given the large in-place resource, geopressured methane could be a virtually inexhaustible source of domestic energy.

Most research conducted by the DOE in the geopressured zones is focused on producing electricity from low-grade heat in the reservoir brine. The DOE should redirect its research efforts and concentrate more on recovering the vast amount of dissolved methane found in geopressured zones. In addition to the DOE's current geopressured program, novel approaches, which utilize traditional engineering principles to maximize gas production and minimize brine production, must also be attempted.

SURFACE COAL GASIFICATION: $40.5 Million

Surface coal gasification is an important technology that can augment future natural gas supplies. A.G.A. projects that, by the year 2000, coal gasification, with virtually no increase in current federal R&D support, would contribute approximately 0.3 Tcf of additional gas supplies.

However, with vigorous R&D support, coal gasification could contribute up to 1.5 Tcf to our supplies.

Contemporary technologies allow significant production of gas from coal; however, substantial research into the gasification process is necessary for synthesized gas from coal to play a role in meeting this nation's future energy needs. Gasification techniques must be developed to accommodate combustion-inhibiting coal "fines." Research must be conducted to develop techniques for gasifying these "fines" and liquid byproducts, and for consolidating "fines" and tars for utilization. Scientific and engineering feasibility studies of advanced generation gasification processes must be conducted to develop a technological database for such processes. In addition, research must be conducted to identify the proper treatment and disposal techniques for gasification waste byproducts.

FUEL CELLS: $23 Million

Gas-fired fuel cells, in a highly efficient electrochemical process, convert the energy content of gas directly into electricity and byproduct heat. This process is much more advantageous than current electricity generation technologies, which rely upon the less efficient combustion process to generate electricity. The electrical conversion efficiency of gas-fired fuel cells is approximately one-third greater than the conversion efficiency of traditional electricity generation. Combining fuel cells with cogeneration equipment could achieve combined electrical and thermal conversion efficiency of 80 percent, compared to a conversion efficiency of 36-40 percent by the typical electric utility. Fuel cells are also environmentally benign.

The DOE has not requested any funding for phosphoric acid fuel cell research, claiming that phosphoric acid fuel cell research is sufficiently mature to be exploited commercially. We disagree. More funding for phosphoric acid fuel cells is necessary to develop advanced cell cooler designs and advanced cathode catalysts that could double the power density of individual cells. Improved techniques for controlling phosphoric acid electrolyte and increasing the efficiency of DC to AC power inverters must be achieved. Research must also be conducted to develop second-generation molten carbonate fuel cells capable of processing gases containing sulfur and chlorine, as well as to develop other advanced, direct conversion concepts.

CONSERVATION: $40 Million

(1) CNG Vehicles

Broad development of vehicles fueled by compressed natural gas would serve the national interest by reducing the oil industry's monopoly in the vehicle fuel market. Wide use of natural gas as a vehicular fuel could also lead to improved air quality, since the emissions from CNG vehicles contain only a fraction of the nonmethane hydrocarbons, carbon monoxide, and nitrogen oxide produced by gasoline-powered vehicles. Furthermore, unlike gasoline-powered vehicles, CNG vehicles emit almost no sulfur oxides or particulate matter. Fleet use of CNG vehicles in congested cities would provide a significant benefit to those areas where air quality improvement is most critical.

Fundamental research is necessary to acquire a thorough understanding of the intricacies of gaseous fuel carburetion, manifolding, combustion, power optimization and emissions control so that natural gas can become universally accepted as a transportation fuel. Further research into novel gas compression concepts is necessary to advance the development of compressor technology. Research must also be conducted to increase the understanding of gas storage technology, particularly the fundamental principles of natural gas adsorption, absorption, clathration and catalysis.

(2) Combined Fuels/Select Gas Use

Select gas use or "select use," a relatively new concept in fuel combustion, entails the burning of natural gas with less environmentally attractive fuels in the same or separate combustion units for environmental control purposes. Studies have shown that burning natural gas with coal, municipal solid wastes, toxic wastes or coal-water mixtures can reduce sulfur dioxide, nitrogen oxides and particulates emissions.

Basic research and mathematical modelling are necessary to obtain a fundamental understanding of the combined fuel combustion process. Research is also needed to develop the techniques for burning natural gas with other fuels in the same combustion unit, including the assessment of burner configurations and fuel characteristics. For example, research is required to understand the combustion of natural gas with coal-water mixtures to resolve problems -- such as flame instability and deratings -- that are normally associated with burning coal-water mixtures alone.

UNDERGROUND COAL GASIFICATION: $8 Million

Underground coal gasification is the process whereby coal is burned underground, in formation, generating a low-Btu or medium-Btu gas. The coal is gasified by drilling boreholes into the coal seam, igniting the coal and injecting air or steam and oxygen into the reaction zone. The hot gas is forced through the seam to an exit borehole where it is carried to the surface and processed to remove impurities. The gas can then be used directly as an energy source or can be upgraded to pipeline quality through catalytic methanation. Underground coal gasification could increase substantially the recoverable coal resource base, 93 percent of which presently cannot be recovered using conventional mining techniques. Moreover, underground coal gasification offers potential environmental, economic and safety advantages over conventional mining.

Extensive field testing is necessary to understand the technological basis for linking the vertical wells through the coal seam and controlling the movement of the reaction zone. Extensive environmental monitoring is also required to analyze and control the potential contamination of surface water and local aquifers (geological formations containing water), and to control surface subsidence.

ADVANCED RESEARCH & TECHNOLOGY DEVELOPMENT: $13.5 Million

The Advanced Research and Technology Development program generally provides a technology base for ongoing fossil energy projects and for advanced process development. Current research needs include improving the understanding of the interactions of coal gasification processes in a fluidized-bed environment; improving the understanding of the interaction of gasification catalysts with carbon/steam and carbon/hydrogen reactions; developing advanced processes for low-cost synthesized gas; developing lower-cost acid-gas cleanup processes; and continuing efforts to assess advanced cleanup technology for alkali metals, particulates and tars.

LIQUEFIED NATURAL GAS SAFETY: $4 Million

Liquefied natural gas (LNG) is natural gas which is liquefied by reducing its temperature to minus 260°F. The advantage of this technique is that it permits the transportation of large volumes of gas over great distances and terrain not otherwise suitable for pipelines.

Potentially, the resource base for LNG includes any oversees gas reserves beyond those required for local consumption. However, one difficulty with transporting LNG has been that there is virtually no experimental data on the behavior of large spills.

A.G.A. strongly supports the construction of the DOE Liquefied Gaseous Fuels Spill Test Facility site for evaluating spills of various materials, including LNG. In FY 1985, DOE solicited comments from industry on the design of the facility; additional funding is necessary to complete construction and thorough checkout of the facility. The test facility will allow researchers to evaluate spills of liquefied gases at magnitudes far greater than has been previously possible. The research that needs to be conducted includes investigating equipment vulnerability to natural forces, the ability of dikes to contain large spills, the advantages of in-ground storage and the behavior of spills on different surfaces.

BIOMASS: $18 Million

Since the supply of organic and waste materials is virtually unlimited, supplemental methane supplies from biomass and waste conversion can add significantly to the total future gas supply picture. Developing energy from biomass also would promote the environmental benefit of productive use of currently "useless" materials. However, the quality of the gas produced and a suitable processing technique are important concerns that inhibit the widespsread use of these potential gas resources.

The sources of biomass, land and marine plant matter, must be tested to determine the appropriate technology for producing high-quality gas from the resource. Because sources vary greatly in content, the technologies must be flexible. To produce gas economically, processing techniques must be improved to increase conversion efficiencies.

CONCLUSION

The natural gas industry recognizes that, to reduce the current budget deficit, federal spending for FY 1986 will be subject to careful Congressional scrutiny. Expenditures for natural gas-related research should not be exempt from such scrutiny. What the natural gas industry suggests for FY 1986, however, is a redirection of funds, rather than an increase, for gas-related R&D. If Congress responds to the gas industry's call for redirection, the nation could enjoy benefits of increased gas supplies and efficient gas utilization without increasing DOE's overall R&D budget or otherwise contributing to the federal deficit.

Mr. FUQUA. Thank you very much, Mr. Baly.
Mr. Webb.

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE, WASHINGTON, DC

Mr. WEBB. Thank you, Mr. Chairman and members of this committee. I appreciate the opportunity to appear before you today to discuss GRI's views in fiscal year 1986 recommendations for gas-related research in the DOE programs of fossil energy and renewables.

GRI is recommending a program of long-term gas research in at a level of $156 million. Central to this recommendation is the fact that GRI is planning to fund $164 million of research in 1986 in near-term gas-related research; much of it in these same program areas.

Also, Mr. Chairman, the Gas Research Institute did submit a response to the clean coal initiative by the administration that would require $8 million in 1986.

Finally, we want to support the AGA testimony specifically in establishing within the Office of Energy Research Programs a $35 million initiative to really establish a Hydrocarbon Geosciences Research Program.

The total budget for the Office of Energy Research was requested in 1986 of $1.74 billion. Most of that, though, is really dedicated to high-energy physics, magnetic fusion; long-range generic research that is very important to this Nation. At the same time, we know that through the next 25 to 30 years, that our resources are going to be from fossil fuels. We need to establish the same sort of basic Generic Geosciences Program in the Office of Energy Research at a minimum level of $35 million in the 1986 budget cycle. Establishing this Generic Geosciences Research Program should become a top national energy policy and I would urge this committee in your oversight study and hearings you're doing on general basic research policy for the Nation, to consider this as one of your top initiatives and priorities.

Today my testimony will concentrate on the proposed long-term DOE gas research programs previously approved by Congress. Many of these projects are cofunded and coordinated with GRI and other industrial gas firms. Even though GRI is not a Government contractor and we do not accept Government funds, we do cofund and coordinate most of our research with DOE. Therefore, the actions of Congress on the fiscal year 1986 DOE budget have a direct impact on the gas industry research programs.

Before I go to three specific recommendations in the budget, Mr. Chairman, I would like to discuss three policy issues that I think everyone ought to keep in mind in looking at this year's budget.

The first of which has already been discussed this morning is that the budget has tremendously shifted from energy R&D to other types of activity. In 1986, the total budget after you take out the business-related functions in the Department of Energy, for energy R&D is $2.3 billion, or only 20 percent of the program. I realize there are other priorities, but that means that there has been a constant reduction over the past 6 years in the amount of priority assigned to energy R&D spending. The end result, if this trend continues, is increased reliance once again on unstable foreign imports.

At the same time, I think another way to look at the budget in looking at the funding priorities is to look at where our energy resources are going to be derived over the next 25 years and seeing where DOE is placing their energy research funding priorities. DOE would assign only 20 percent of its funding to fossil fuels research, yet the United States is projected to meet 75 percent of its energy needs in the year 2010 from fossil fuels. I think a balanced national energy program requires a sharp shift in research funding priorities based on where our energy allocation and resources are going to be from.

Finally, the Assistant Secretary Vaughan this morning testified that the proposed 1986 fossil energy program budget is down approximately 30 percent from the fiscal year 1985 appropriated levels. One thing, though, that I think is important to realize is that the budget authority is only $158 million and to fund the programs as proposed, even at the reduced level, requires $86 million in previously appropriated funds including approximately $46 million of requested deferrals. In order to fund the reduced program as they propose, requires Congress to terminate many projects that have been previously approved and were meant to be underway in this fiscal year.

If you look at the gas-related research funding, it drops from a level of about $124 million to a level of only $74 million, again, in our estimate, not a viable long-term core program to balance out the near-term research the gas industry has picked up on its own.

Finally, one other policy issue. The long-range impact for an unbalanced energy research policy that essentially ignores research on fossil fuels, I think is made clear when you examine the outlook for liquid fuel. Petroleum consumption is forecast to increase from 15.2 million barrels a day in 1983 to 17.7 barrels per day for the year 2010. During that same timeframe, domestic production is estimated to decline anywhere from 1 to 2 million barrels a day from today's production levels. The end result would be imports of approximately 9 to 10 million barrels a day in the year 2010, the greatest demand for imports since the 1977 high of 8.8 million barrels per day.

National energy policy as modified by Congress has stressed and encouraged development of ample supplies of domestic energy resources and the more efficient use of energy to replace the dependence on imported oil. A central element of this policy has been congressional initiatives to restore funding for critical long-term fossil conservation and renewable programs in DOE. I would encourage Congress to again provide adequate funding in critical research areas if we're to successfully develop the full potential of our vast domestic energy resources.

Natural gas will continue to be an important role in a highly competitive energy mix through the remainder of this century and developing the technology that's required requires a budget in DOE of approximately $156 million in the fossil and renewables budget. In the past 4 years, Congress has recognized the need for a consistent long-term program in these areas and appropriated approximately $125 million each year for this research. The gas industry is essentially seeking continuation of this trend in 1986.

Before I get to my specific budget recommendations, let me point out that GRI has assumed the majority of the near-term gas-related research through the support of our member companies. Our budget in 1986 we will request from the FERC $164 million, a $32 million increase over the 1985 budget. At the same time, our budget has shifted from being under 40 percent in near-term activities in 1981 when the administration announced its new policy shift, to over 80 percent in our 1985 budget. So, essentially, we have through our member companies, picked up the near-term research under the administration's revised policy. The administration should enter into a partnership with the gas industry for carrying out its responsibilities of continuing the critical long-term, high-risk, gas-related research at a comparable funding level.

I would like to discuss three specific funding recommendations real briefly, Mr. Chairman, that the GRI has. In the area of coal gasification, the $40 million as recommended by AGA, two items in there I think are important. We have been working with DOE since 1981 on agglomerating ash fluidized bed processes. Those processes we think should be continued because of their potential to develop advanced processes that can use the high sulfur eastern coals and also handle coal fines. That would require approximately $9 million in the DOE fossil energy coal gasification budget. In the response to Congress' clean coal initiative, GRI submitted a proposal that would propose a cofunded program between DOE and industry to build a coal gasification test facility. The test facility should be located adjacent to an existing large coal conversion facility in order to take advantage of existing utilities and support systems. DOE last year did a limited study that it concluded this type of an approach, colocated with an existing large coal conversion facility, would be approximately one-third the cost of building a stand-alone facility. To do the initial design and planning for the test facility would require $8 million in fiscal year 1986.

In the area of fuel cells, I would like to point out that the gas industry and GRI in 1982 made a major commitment and picked up total funding for the ongoing near-term research in the fuel cell field tests. We have funded $69 million from 1981 through 1985 in picking up this near-term responsibility. At the end of 1984, 33 of the 47 units had been installed in 15 States and we've accumulated over 72,000 hours of operating experience. However, simultaneously in late 1982, this administration signed a 4-year technology development program, cofunded on a 50-50 basis with GRI, to do the long-term research. That program runs through 1986; in order for DOE to meet the 4th year of that commitment, it requires a funding of $7 million. GRI will continue to focus its near-term research in this joint program on the engineering aspects and the manufacturing techniques to get ready to assist that manufacturing in making a commercial offering. All we're really saying here is that DOE should finish the joint program we undertook back in 1982. At the same time, we do think $4 million of research for solid oxide fuel cells should be considered because it has a potential for much higher efficiencies in the long run and it operates at much higher temperatures so you get more useful waste heat generated that can be used in industrial applications.

Finally, Mr. Chairman, in the area of renewables in the biomass program, GRI would recommend funding of $18 million. The unique advantages of biomass make it an excellent candidate for many regions of the United States that lack conventional energy resources. As you're aware, GRI began a program in 1982 at the University of Florida to do long-term basic research funded on a 50/50 joint basis with the State of Florida and GRI. We think more of this activity should be encouraged and DOE should fund approximately $4 million in the 1986 budget for regional biomass programs. Also, DOE should fund about $4 million for biomass growth in harvesting research, and we would recommend $1.5 million for waste conversion.

In summary, a consistent Federal energy policy that provides adequate funding for long-term gas research in DOE's fossil and renewables program is needed in order to insure affordable domestic natural gas supplies and efficient utilization in the future. The gas industry recommends that DOE's 1986 budget for gas-related research in these two program areas be $156 million, of which $35 million is actually a redirection in the Office of Energy Research program to establish a hydrocarbon geosciences research effort.

GRI is planning to spend $164 million in 1986, essentially matching our recommendation on a dollar-per-dollar basis for near-term research. This completes my testimony, Mr. Chairman, and I would like to be allowed to submit my statement for the record and be glad to respond to any questions you or the members might have.

[The prepared statement of Mr. Webb follows:]

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
MARCH 6, 1985

I appreciate the opportunity to appear before you today to discuss the Gas Research Institute's (GRI) views and FY 1986 budget recommendations for gas-related research in the Department of Energy's (DOE) Fossil Energy and Renewables programs. Consistent with past Committee action, GRI is again recommending a core program of long-term gas research in DOE at a $156 million funding level in FY 1986. Central to this recommendation is the fact that GRI is planning to equal this DOE funding by submitting a research plan to the FERC requesting $164 million in 1986 to fund mostly near-term gas research. Also, in response to last year's Congressional action to establish a Clean Coal Technology R&D Fund, GRI is recommending a new initiative requiring FY 1986 DOE funding of $8 million. GRI is also proposing within the $156 million recommendation a redirection of $35 million within the $1.74 billion budget request for DOE's Office of Energy Research programs to establish a viable program in geosciences related to deep source gas, methane hydrates, geopressured gas, and related materials technology. These resources have been estimated to contain at least 2,000 trillion cubic feet (Tcf) of recoverable gas--the equivalent of more than a 100-year supply at current consumption rates. Despite this potential, today, DOE programs conducted by the Office of Energy Research are nearly totally dedicated to nuclear-related research with less than $10 million allocated for petroleum geosciences. Establishing this generic geosciences research program should become a top national energy priority. Today my testimony will concentrate on the proposed long-term DOE gas research programs previously approved by Congress. Many of these projects are cofunded and coordinated with GRI and other industrial firms.

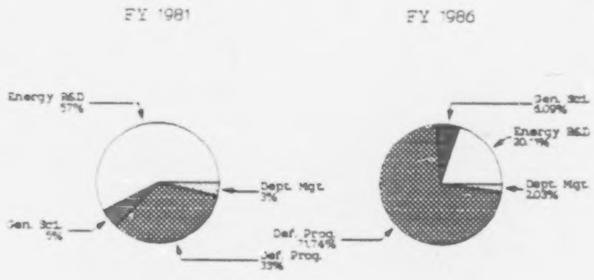
GRI is an independent, not-for-profit scientific research organization that plans, manages, and develops financing for a cooperative research and development (R&D) program for the mutual benefit of the gas industry and its present and future customers. The R&D program is implemented through contracts with research organizations, engineering and other professional service firms, universities, energy companies, and manufacturers. Funding for the GRI R&D program is provided primarily through regulated sales of natural gas. An R&D funding unit, approved annually by the FERC, is incorporated into the cost of gas of GRI's 31 interstate pipeline company members. GRI members, subject to appropriate state approvals, also apply a similar charge to their intrastate and direct industrial sales. This funding arrangement enables GRI to conduct a truly comprehensive R&D program at a cost to the typical residential gas customer (in 1984) of about $1.40 per year. Even though GRI is not a government contractor and does not accept federal funds, GRI cofunds and coordinates many of its research programs with DOE; therefore, the actions of Congress on the FY 1986 DOE budget have a direct impact on the gas industry's research program.

FEDERAL ENERGY R&D FUNDING POLICY SHIFTS

In examining the DOE FY 1986 budget request, it is important to review the shift in priority assigned to energy R&D by this Administration. Comparing the FY 1981 and 1986 requests after deleting the business-related functions such as buying oil for the SPR, nuclear waste fund activities, and business enterprises, a dramatic decline in energy R&D becomes very evident. This decline is partly obscured since the Administration included $2.4 billion of weapons R&D and $685 million of general science activities in the FY 1986 energy R&D budget category. When these non-energy-specific items are removed from the energy R&D budget, in FY 1981 the Administration requested an R&D and defense programs budget of $10.3 billion with about 60 percent, or $5.9 billion, of the request going for energy R&D. However, over the past four years, there has been a steady decline in energy R&D support while defense programs have more than doubled from $3.44 billion to $8.06 billion requested for FY 1986. In FY 1986, the Administration requested only 20 percent, or $2.3 billion, be allocated to energy R&D programs, while over 70 percent is for defense activities.

If national energy policy continues this trend of constant reduction in energy R&D spending, we will soon find ourselves without technology for full development of domestic sources of energy. The result will clearly be to increase our reliance, once again, on unstable foreign imports

DOE RESEARCH & DEVELOPMENT AND DEFENSE PROGRAMS



'Defense Programs' includes research

DOE RESEARCH & DEVELOPMENT AND DEFENSE PROGRAMS
($ Billions)

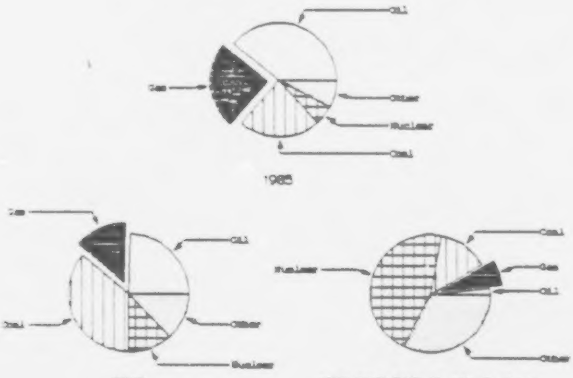
	FY 1981	FY 1986
Energy R&D	$ 5.922	$ 2.295
General Sciences	.523	.685
Department Management	.362	.299
Defense Programs	3.443	8.060
TOTAL	$10.250	$11.269

NEED FOR REVISED FEDERAL ENERGY R&D PRIORITIES

The urgency in establishing a consistent federal policy of providing adequate funding for long-term fossil fuels research is evident when you examine where the nation will obtain its energy supplies during the next 25 years. Both private and federal forecasts agree that the U.S. will continue to rely on oil and gas for over 60 percent of its energy needs in the year 2000 and approximately 40 percent in 2010.

A revealing illustration of the imbalance between DOE funding priorities and the actual national research needs is to contrast DOE FY 1985 R&D budgets by energy resource compared to current and future energy resource utilization. As shown, DOE would assign only 20 percent of its funding to fossil fuels research, yet the U.S. is projected to meet 75 percent of its energy needs in the year 2010 from oil, gas, and coal. It is impossible to have a balanced national energy program without a sharp shift in research funding priorities.

U.S. ENERGY NEEDS



1985

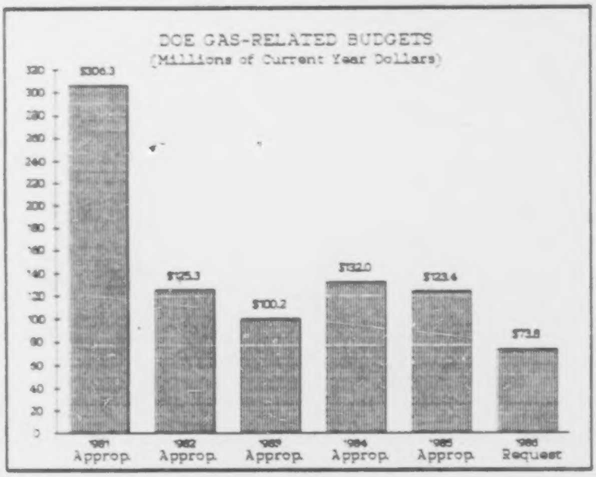
2010

1985 DOE R&D Fuels Budget
(Excluding weapons and basic research)

DOE FY 1986 ENERGY R&D FUNDING PRIORITIES

While a balanced energy policy would establish a proportionate relationship between R&D funding and the actual production of U.S. energy resources, DOE has proposed an unbalanced budget again in FY 1986. The funding proposed for weapons activities is three times the proposed energy R&D budget. The budget for nuclear energy research is so much larger than the combined DOE research programs in oil, gas, and coal that it totally makes a myth of a balanced energy program.

To stress the importance of providing a balanced federal research program, in last year's testimony on the DOE budget, Secretary Hodel stated, "I believe that energy has an importance far beyond most commodities because directly and indirectly energy is significant to every aspect of the U.S. economy . . . Another belief I hold very strongly is that overreliance on any one energy source is unwise and that a balance among energy resources is needed." GRI agrees with these positions. However, to implement this policy, DOE must provide a stable funding base for long-term, high-risk gas-related research while the regulated gas industry is increasing its near-term research funding. In contrast to the stated policy, the proposed FY 1986 Fossil Energy program is $242.7 million--down approximately 30 percent from the FY 1985 appropriated level of $347 million. More importantly, the request for new budget authority is only $157.9 million. To fully fund the program as proposed requires the use of $85.8 million in previously appropriated funds including approximately $46 million of deferrals. This would result in programs that Congress has already approved being terminated in order to fund even the drastically reduced program proposed by DOE for FY 1986. The proposed reduction in gas-related research funding in the total DOE energy R&D program is even more startling. It drops from a level of $123.4 million in FY 1985 to only $73.8 million in FY 1986. In summary, the Administration's proposed FY 1986 gas research budget is not consistent with its own policy and certainly does not provide stable funding for a core program of long-term gas research.

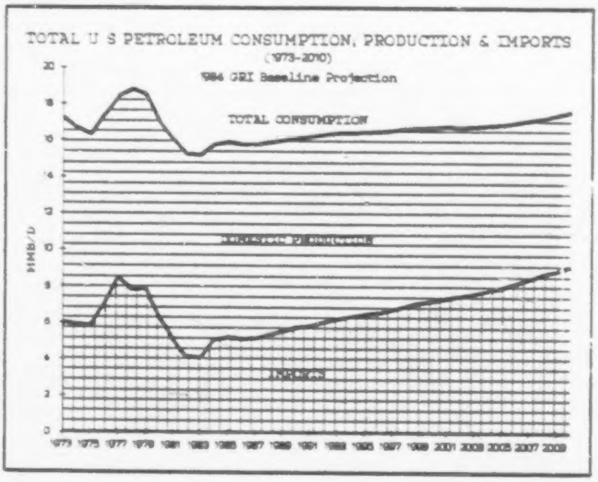


LIQUID FUELS OUTLOOK

The long-range impact of an unbalanced energy research policy that essentially ignores fossil fuels is made clear when you examine the outlook for liquid fuels. A major issue highlighted by the 1984 GRI Baseline Projection of U.S. Energy Supply and Demand is the increasing total demand for liquid fuels and oil imports. The 1984 GRI Baseline Projection assumes steady economic growth at average historical rates, only moderate increases in the real dollar-denominated world price of oil, and that continued conservation trends will moderate demand growth in all of the energy end-use sectors. Still, it is estimated that U.S primary energy consumption will reach nearly 107 quads in the year 2010, with petroleum contributing 33 percent (35 quads) of the total. By comparison, in 1983 the U.S. consumed 30 quads of petroleum.

Petroleum consumption is forecast to increase from 15.2 million barrels per day in 1983 to 16.7 million barrels per day in 2000. In the extended projection, petroleum consumption reached 17.6 million barrels per day by 2010. While domestic consumption is increasing, the domestic production of crude is expected to decline throughout the projection to 7.8 million barrels per day in 2000--a reduction of nearly a million barrels per day from today's production levels. The Baseline Projection, when compared to the major oil companies' forecasts, is relatively optimistic concerning U.S. crude oil production. The oil companies expect domestic crude production to decline faster between 1983 and 2000 to around 6.5 million barrel~~s~~ per day in 2000.

The net result of an increasing demand for petroleum with a simultaneous decline in domestic crude production is an increased dependence on foreign sources of crude. The Baseline Projection expects imports to increase to 9.2 million barrels per day in 2010--the greatest demand for imports since the 1977 high of 8.8 million barrels per day. The lower estimates of U.S. crude production from the oil companies would result in even higher levels of imports--over 10 million barrels per day.



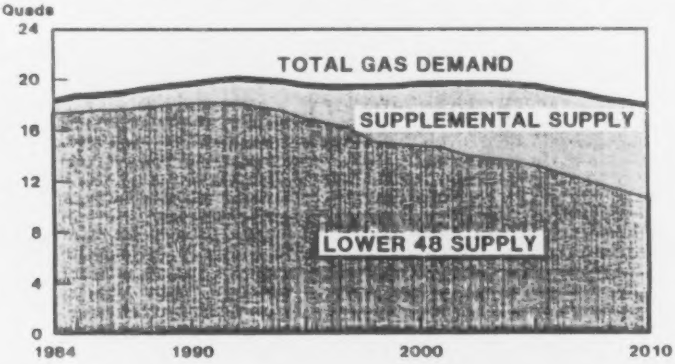
By the 1990s, the non-OPEC countries will face declining production levels. As a result, the U.S. may be faced with the prospect of again relying on OPEC oil as the major source of its crude oil imports. Both Chevron and Conoco foresee OPEC production increasing to 21.55 million barrels per day in 1990 and to nearly 29 million barrels per day in 2000. It seems probable OPEC will require significant premiums in real terms to increase production to these levels, which would lead to dramatic escalations in the world price for crude at the turn of the century.

National energy policy as modified by Congress has stressed and encouraged development of ample supplies of domestic energy resources and the more efficient use of energy to reduce the dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for critical long-term fossil, conservation and renewable energy research programs in DOE. Maintaining adequate program funding is critical if the U.S. is to successfully develop the full potential of our vast domestic energy resources.

NEED FOR DOE FUNDING OF NATURAL GAS R&D

Natural gas will continue to maintain an important role in a highly competitive energy mix throughout the remainder of the century. The GRI Baseline Projection shows that the role of gas after the year 2000 will diminish without additional research to develop supplemental gas supplies based on new and improved technologies. In the post-2000 portion of the Projection, the demand model exhausts the gas supplies provided at the then-prevailing average market clearing price while there is still unfulfilled demand that could be captured by gas at this price. Independent GRI analyses indicate that any projected shortfall in the marketable gas supply can be met by incremental production from tight gas formations through development and use of new or improved technologies.

GAS SUPPLY
1984 GRI Baseline Projection



Establishing the technology base to fully develop these supplemental supplies requires a lead time of 10 to 15 years. The current gas deliverability surplus and softening of world oil prices provides us the opportunity to pursue this critical technology development in an orderly fashion rather than on a crash basis. While we have the time, we must seize this opportunity to strengthen our domestic energy production potential. To do so, the gas industry is recommending a total of $156 million for gas-related research in the DOE Fossil and Renewables budget. Thirty-five million dollars of the $156 million recommendation is a redirection within the DOE Office of Energy Research to establish a viable geosciences hydrocarbon research program. GRI is recommending $122 million for gas-related research for Fossil Energy and $34 million for Solar and Renewables. This long-term DOE program will be supplemented by the $164 million GRI budget in 1986 which focuses on near-term research.

GAS INDUSTRY'S RECOMMENDED FY 1986 DOE GAS-RELATED FUNDING
($ Millions)

Advanced Research and Technology Development	$ 13.5
Surface Coal Gasification	40.5
Underground Coal Gasification	8.0
Fuel Cells	23.0
Unconventional Natural Gas	35.0
Geopressured Methane	16.0
Eastern Oil Shale Gasification	2.0
Biomass	18.0
TOTAL	$156.0

In the past four years, Congress has recognized the need for a consistent long-term gas program and has appropriated approximately $125 million each year for this research. The gas industry is seeking a continuation of this trend in FY 1986. These central themes of funding a long-term gas research program in DOE at the same level as GRI's budget, establishing a viable geosciences program, and starting a new initiative consistent with the goals of the Clean Coal Technology R&D Act are just sound national energy policy.

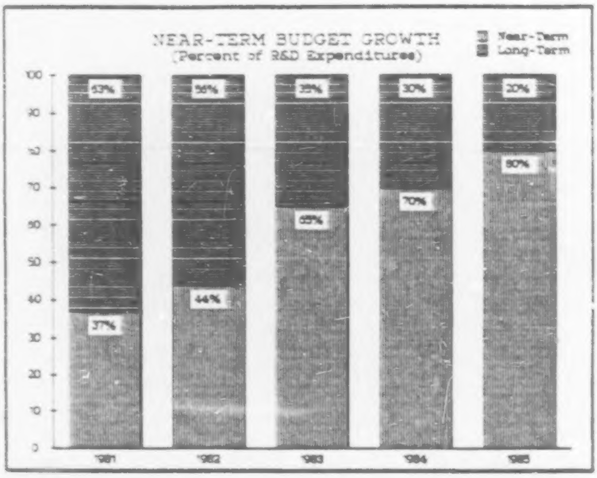
GAS RESEARCH INSTITUTE'S 1986 BUDGET

In contrast to the DOE policy of reducing funding of long-term gas research, the response of the gas industry to the federal R&D policy of industry's funding more of its own near-term research has been rapid and very impressive. GRI will propose to its Board of Directors in April a 1986 budget of $164 million--an increase of $32 million from the FERC-approved 1985 budget of $132 million.

National energy R&D policy is a major factor influencing the GRI R&D program. In response to the evolution of government energy R&D funding policy over the past four years, GRI's Board of Directors, with input from advisory committees, adopted the following strategy:

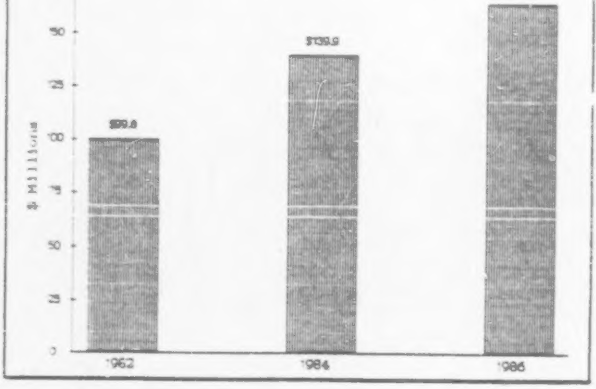
- GRI should assume a leadership role in near-term gas-related R&D.
- GRI should reduce funding for long-term research but continue to seek coordinated funding with DOE where appropriate.
- GRI should expand its already extensive efforts to obtain coordinated funding from industry.

As the level of federal funding and support has declined since 1981, essential near-term gas research was no longer funded by DOE. GRI responded to this by cancelling or deferring some of its own projects with a longer-term payback and concentrating its limited resources on projects with a more immediate return to the industry and ratepayers. This resulted in a radical change in the direction and makeup of GRI's program. While near-term research accounted for under 40 percent of GRI's R&D budget in 1981, it accounted for 80 percent of the 1985 budget.



GRI's emphasis on near-term research has significantly contributed to increased levels of coordinated funding from private industry in GRI's programs. Industrial coordinated funding has increased from $8.8 million in 1979 to an expected $35 million in 1984.

The natural gas industry has assumed responsibility for funding the near-term research and development by increasing its budget over the past four years from of $100 million in 1982 to $164 million in 1986. This will equal the recommended DOE funding for a core program in long-term gas-related research. The Administration should enter into a partnership with the gas industry by carrying out its responsibility of continuing the critical long-term, high-risk research at a comparable funding level.



RECOMMENDED DOE FY 1986 LONG-TERM GAS-RELATED RESEARCH PROGRAM (FOSSIL ENERGY)

Discussed below are several important long-term areas of gas research that are consistent with the Administration's policy guidelines, have been supported previously by this Committee, and require continued federal funding.

	FY 1984 Appropriation	FY 1985 Appropriation	GRI FY 1986 Recommendation
Surface Coal Gasification	$36.79M	$31.99M	$40.5M

While the U.S. is currently experiencing a glut in natural gas supplies, in the post-2000 period, GRI projections show gas consumption declining sharply without the development of new supplemental supplies as a result of a reduction in the gas available from lower-48 production. One of the most promising, abundant long-term gas supply resources is the conversion of coal to gas. In order for coal gasification to have a significant impact, it is necessary to validate the needed economic and design data by the early 1990s.

Of particular importance is the development of advanced processes that can use high-sulfur Eastern coals and coal fines. In 1981 GRI and DOE jointly reviewed test results and technical and economic evaluations and decided to concentrate on the further development of the Westinghouse agglomerating ash, fluidized bed process. Continued federal support in FY 1986 of $9 million is needed for this technology development. Funds should be used to continue the process development unit (PDU) tests, cold-flow test facility (CFTF), and laboratory research.

As a result of Section 321 of the Continuing Appropriations for Fiscal Year 1985 (PL 98-473), GRI has submitted a proposal in response to the Department of Energy's solicitation. The proposal recognizes that as a result of previous GRI/DOE efforts, there are emerging technologies that can utilize caking coals located in the East and can make a contribution to lower cost substitute natural gas (SNG) from all ranks of coal. A test facility is required to provide a validation of the performance of these technologies at a sufficient scale and under conditions that will enable users to seriously consider commercial ventures when the need for SNG increases. The gasifier should be oxygen-blown and operate at a pressure of 450-500 psi in order to provide data relevant to SNG production. The facility should be constructed to accommodate the integrated slip-stream testing of the advanced downstream processing components that would be used to upgrade the gasifier products to a pipeline quality gas. GRI's proposal involves cost sharing by both industry and the Department of Energy to build a coal gasification test facility at an existing large-scale coal conversion facility to take advantage of the infrastructure and support systems that are already in place. The Department of Energy, following a limited study, has concluded that a program of this character could be carried out at approximately one-third the cost of a stand-alone facility. Funding of $8 million in FY 1986 is required to provide the detailed design and planning for the test facility.

In addition, federal support is needed to continue research programs in improved catalysts, materials, components, and instrumentation. Significant advancements in the economies of coal gasification can result from improvements in downstream processing systems which currently comprise about one-third of the installed plant investment. A viable DOE program requires funding at levels consistent with the past two years' appropriations of $8.5 million.

	FY 1984 Appropriation	FY 1985 Appropriation	GRI FY 1986 Recommendation
Underground Coal Gasification	$6.0M	$5.76M	$8.0M

Underground coal gasification offers a method of utilizing coal resources without the need for mining by gasifying the coal in place. As a potential source of cost-competitive pipeline-quality gas, underground coal gasification may be able to tap those vast coal deposits that would not be economically recoverable using existing or anticipated strip or deep mining methods. At the present time, underground gasification must be classed as a high-risk, high-payoff technology. DOE has estimated that of the 6.4 trillion tons of domestic coal, only 450 billion tons are currently economically recoverable by existing techniques. Underground gasification could potentially utilize an additional 1.8 trillion tons. If only 10 percent of this resource is suitable for underground gasification, it could produce more than 1,000 Tcf of SNG.

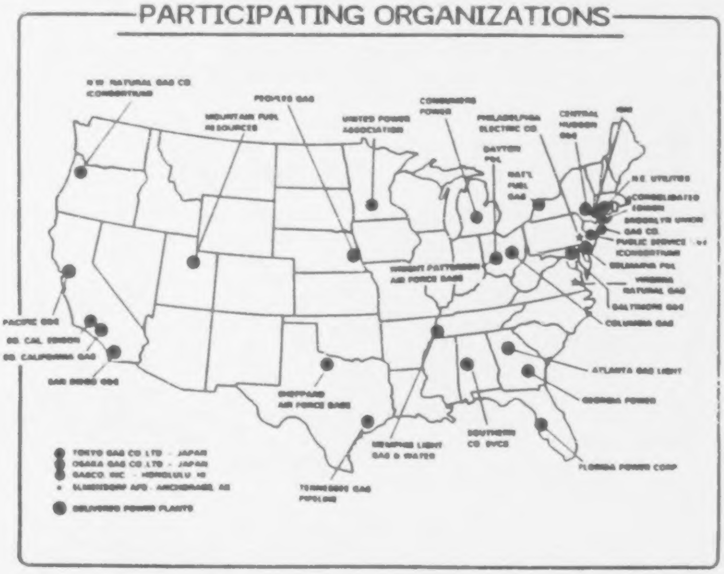
GRI is currently negotiating a cooperatively funded program with the Department of Energy and industry on a 50-50 funding basis. During 1985-86, a series of field tests will be conducted at Centralia, Washington, to demonstrate the Controlled Retracting Injection Point (CRIP) technology at a larger scale than that conducted to date. These tests will be conducted in the seam outcrop or in a highwall of the mine, will be of 60 to 100 days duration, will gasify up to 20,000 tons of coal in two parallel rows of wells, and will generate multiple cavities in each burn. Final testing will be conducted on multiple wells to establish the important interactions between well design, gasification kinetics, and gas processing to determine commercial application of the CRIP technology. The goal of the test is to provide technical and economic evaluation of the CRIP method for controlling average gas quality. A performance comparison of vertical and slant production well systems and of interacting versus non-interacting burn cavities also will be evaluated. Following the Centralia tests with subbituminous coals, a test program will be developed to evaluate the CRIP technology with bituminous coals at an Eastern site. This site is expected to be similar to the Centralia site to permit translation of the Centralia data to bituminous coals.

It is recommended by GRI that $4 million be provided by DOE for the CRIP test to be cofunded with industry; $2 million be used for environmental support; and $2 million be used to evaluate and plan an Eastern coal test.

	FY 1984 Appropriation	FY 1985 Appropriation	GRI FY 1986 Recommendation
Fuel Cells	$16.2M	$17.82M	$14.0M

A fuel cell is a cogeneration power plant that uses an electrochemical process to convert natural gas to hydrogen, react the hydrogen gas with oxygen from the air, and produce electricity, heat, and water. Installed onsite at a multifamily residential, a commercial, or a light-industrial building, the fuel cell power plant can supply all of the electrical and heating requirements of the building with less energy than is now required for just heating.

The gas industry and GRI in 1982 made a major commitment in funding for onsite phosphoric acid fuel cell systems to offset the loss of DOE funds for near-term research. The Gas Research Institute has now totally assumed the cost of the joint DOE/GRI program to field test the 47 phosphoric acid fuel cell units. Fuel cells are currently being manufactured, shipped, and installed in locations throughout the country to test the operational feasibility of the 40 kW power plants in an appropriate mix of actual utility environments. As of the end of 1984, 33 of the 47 units had been installed in 15 states and had accumulated 72,000 operating hours.


PARTICIPATING ORGANIZATIONS
N W NATURAL GAS CO (CONSORTIUM)
PEOPLES GAS
MOUNTAIN FUEL RESOURCES
UNITED POWER ASSOCIATION
CONSUMERS POWER
PHILADELPHIA ELECTRIC CO
CENTRAL HUDSON GAS
DAYTON P&L
NAT'L FUEL GAS
N E UTILITIES
CONSOLIDATED EDISON
BROOKLYN UNION GAS CO
PUBLIC SERVICE (CONSORTIUM)
VIRGINIA NATURAL GAS
BALTIMORE G&E
COLUMBIA GAS
WRIGHT PATTERSON AIR FORCE BASE
PACIFIC G&E
SO. CAL EDISON
SO. CALIFORNIA GAS
SAN DIEGO G&E
SHEPPARD AIR FORCE BASE
MEMPHIS LIGHT GAS & WATER
SOUTHERN CO SVCS
ATLANTA GAS LIGHT
GEORGIA POWER
FLORIDA POWER CORP
TENNESSEE GAS PIPELINE
TOKYO GAS CO LTD - JAPAN
OSAKA GAS CO LTD - JAPAN
GASCO INC - HONOLULU HI
ELMENDORF AFB - ANCHORAGE AK
DELIVERED POWER PLANTS

A separate four-year technology development program was initiated in late 1982 under a 50-50 cofunded joint effort with DOE and GRI for the purpose of increasing reliability and lowering the costs of these onsite fuel cell systems. The DOE-funded elements of this four-year program requires $20 million for this research with the manufacturer, United Technologies Corporation (UTC). The FY 1986 funding required for the DOE commitment is $7 million. The DOE work concentrates on the fuel cell stack; the fuel processing system, including catalyst research; the inverter; and specialty heat exchangers. The parallel $20 million GRI-funded elements of this four-year joint program concentrates on the near-term aspects of system engineering, coolant system improvements, manufacturing techniques, and improved catalysts.

It is anticipated a commercial offering will be made in late 1986 by UTC to the gas utilities participating in the field tests.

Although phosphoric acid fuel cells show considerable promise for use in commercial, multifamily residential, and light-industrial applications, their use is limited in industrial applications that require higher-quality thermal energy. Advanced fuel cells (solid oxide) can operate at a higher temperature than phosphoric acid fuel cells (1300°F to 2000°F vs. 400°F) and, therefore, can provide higher-quality thermal energy. In addition, advanced fuel cells can achieve electrical efficiencies in the range of 50 to 70 percent. In view of the potential high efficiencies and net fuel savings that will be derived from the development of the solid oxide fuel cell, GRI recommends a budget of $4.0 million for FY 1986 for continued work in solid oxide fuel cells.

	FY 1984 Appropriation	FY 1985 Appropriation	GRI FY 1986 Recommendation
Unconventional Natural Gas	$15.5M	$10.24M	$18.0M

Current proved gas reserves in the U.S. amount to slightly more than 200 Tcf--only 12 years of supply at today's consumption rate. However, the U.S. Geological Survey estimates that over 600 Tcf of potential U.S. natural gas reserves are still to be discovered. Unconventional gas reservoirs represent one of the best prospects for adding reserves at a competitive cost. Unconventional natural gas refers to gas contained in geologic formations that generally have not been developed by the oil and gas industry due to the cost and difficulty of producing the gas. The National Petroleum Council's (NPC) estimate of an additional 200 Tcf of reserves through development of advanced technology for just the tight lenticular formations and Devonian shales illustrates the potential and rationale for assigning a high federal priority to this research.

The 1986 GRI unconventional natural gas program of $27 million is coordinated with the DOE R&D program. In the "tight sands", so named because they are much less permeable than conventional sandstone, GRI is working on near-term research projects in blanket sands (broad continuous bands of sandstone formed from ocean sediments) while DOE is conducting work in the long-term lenticular sands (individual, lens-shaped deposits imbedded in shale rock). GRI is now the primary sponsor of this tight sands research with funding in 1986 of $10.3 million.

Federal funds at a level matching the gas industry's $10 million should be appropriated in the DOE FY 1986 budget to continue long-term research on the lenticular sands. This research should continue the multiwell test facility activities to study ways to pinpoint the location and shape of each sands lens and devise methods for extracting the natural gas contained within them. Emphasis should continue the field laboratory efforts to develop improved diagnostic techniques to assist in determining the size, shape, direction, and length of fractures.

DOE research should be continued on recovering gas from Devonian shale. These shales are rock formations of organic-rich clay found in nine Eastern states. They are typically 200 to 1,000 feet thick and lie less than 8,000 feet below the surface. The U.S. Geological Survey estimates that between 500 Tcf to 1,100 Tcf of natural gas could be contained in the Devonian shales. However, better techniques to fracture the shale and link the shales natural fracture systems to the wellbore must be developed to allow the gas to flow. Funding of $8 million by DOE is required in FY 1986 to develop new, improved fracturing techniques and to continue the "Offset Well Experiment." GRI will fund $7.5 million in 1986 for near-term research in the Devonian shales.

GAS GEOSCIENCES RESEARCH IN THE DOE BASIC RESEARCH PROGRAM--$35 Million

GRI is recommending a commitment of $35 million within the $1.74 billion budget for programs in DOE's Office of Energy Research for geosciences research. Three of the most important areas requiring a long-term geosciences/geophysics basic research program are: (1) geopressured gas resources, (2) methane hydrates, and (3) deep source gas. The potential of these long-term gas resources are so huge that if they were successfully developed, they could provide abundant supplies of natural gas for the next hundred years. However, there is so little actual knowledge or understanding of the geochemistry and geophysics of the resources that a major federal effort is required. The DOE basic research programs do not contain funding for generic research in these areas; therefore, a budget redirection is urgently needed to provide up to $35 million in FY 1986.

	GRI FY 1986 Recommendation
Geopressured Resources	$16.0M

Geopressured zone methane is one of the major long range options that could have large potential impacts on the supply of natural gas after the year 2000. These geopressured zones are located along the U.S. Gulf Coast and are sedimentary deposits containing trapped water and gas at higher than normal (hydrostatic) pressure. The water trapped by both faulting and shale barriers in these formations is believed to contain significant quantities of dissolved methane. The sedimentary deposits are up to 50,000 feet thick, and the geopressured zones are contained in these formations beginning from 5,000 to 15,000 feet below the surface. Estimates of the gas in place and ultimately recoverable gas vary widely. Experts have estimated gas in place to be as low as 860 Tcf and as high as 100,000 Tcf. Recent estimates of ultimately recoverable gas through advanced production techniques developed by research vary from 50 Tcf to 1,200 Tcf.

The quantities of gas are extremely large and this potential requires an aggressive research program. The research must include a combination of laboratory and field activities. The field activities should be funded at $10 million and should emphasize:

- obtaining cores of both the sandstone and adjacent shales for laboratory analysis;
- analyses of samples of produced phases with emphasis upon understanding their sources and changes in composition;
- accurate real-time recording of production rates for all four phases (gas, oil or condensate, brine, and solids); and
- utilization of offset pressure monitoring wells and periodic transients in production rate to provide rigorous tests of ongoing computer simulation.

The parallel laboratory research program should be funded at $6 million in FY 1986 and use samples from the field research project to concentrate on topics which require controlled laboratory conditions for measuring values that cannot be deduced from field activities. Examples include:

- PVT studies to define phase changes during production;
- solids analyses to distinguish between formation material and precipatates, including evaluation of scale inhibitors;
- research on brine treatment to minimize cost of environmentally acceptable disposal;
- core analyses on sandstone and shale for quantitative definition of reservoir drive mechanisms; and
- development of accurate computer simulations to predict relative permeabilities, capillary pressures, reservoir drive, fluid properties, and sandstone geometry.

A successful research program combining field and laboratory activities has the potential to optimize the recovery of gas from geopressured reservoirs with reasonable cost to gas consumers.

	GRI FY 1986 Recommendation
Methane Hydrates	$3.0M

Methane hydrates are cages of ice with molecules of natural gas trapped inside. They were first found occurring naturally in 1964 by a Soviet drilling crew exploring in Siberia. In 1981, the drilling vessel "Glomar Challenger" operating off the cost of Guatemala for NSF discovered methane hydrate deposits in the sub-seafloor. Hydrates have also been discovered beneath the permafrost regions of Alaska's North Slope. Even potentially more important, seismic reflections from widely separated regions of the world's oceans indicate a "frozen zone" exists in many of the seafloor sediments, possibly containing methane hydrates.

Perhaps most important is that gas hydrates, which are solid, have the potential to act as barriers to normal fluid movements through the host sediments and may even form seals trapping free gas where the structural and stratigraphy of the rocks themselves would not. Finding this "cap" or seal may lead exploration toward likely areas for natural gas exploration. Because such large areas of sedimentary basins are underlain by permafrost or are covered by water, the volume of gas locked in hydrate reservoirs may be enormous. For example, based on Soviet calculations of hydrated reserves in Siberia, the shallow reservoirs under the permafrost of North America could contain 200 Tcf of such gas. The muds under the deep water along the continental margins of North America have been estimated to contain up to 20,000 Tcf, of which, perhaps, 200 Tcf are in the rocks porous enough to be produced.

To better define this resource and estimate its potential, research is required on sonic techniques and instrumentation necessary to identify hydrates through characteristic sound patterns. Research is also needed on better techniques to determine the electrical resistivity patterns (salty hydrate formations are better electrical conductors that the surrounding unfrozen salt water) to help identify and locate the hydrates. New extraction technologies are required to melt the hydrates or separate the gas from the ice formations. This research requires $3 million be dedicated in the FY 1986 DOE budget.

	GRI FY 1986 Recommendation
Deep Source Gas	$4.0M

Several theories exist concerning the occurrence of deep sources of natural gas. Two major sources hypothesized by scientists are abiogenic and subducted.

Abiogenic gas derives its name from speculation that it was formed by non-organic means; that is, it did not come from the decaying of organic matter. Instead it was formed deep in the earth's mantle during the creation of the earth, and through the ages it slowly seeped to shallower depths.

Subducted gas is thought to be of organic origin, but instead of being formed from layers of compacted sediments, the gas is created when marine organisms and vegetation are pushed deep into the earth by the tectonic movement of the earth's crust. The subducted gas theory would indicate possible locations of rich traps of natural gas some 20,000 to 30,000 feet underground.

These theories remain controversial and a great deal of very basic scientific research remains to be done to resolve the origin of deep source gas. More importantly, understanding the migration routes of this gas could lead to complete new exploration techniques. It could also add several hundred trillion cubic feet of natural gas resources.

Research is needed in new geochemical and geophysical exploration techniques and technologies, ranging from improved real-time diagnostics to control of deep and very deep directional drilling. Radical innovations such as the use of remotely operated "moles" are required. Technology for detecting deep gas using methods such as carbon and helium isotopes is needed. Also better modeling modes of entrapment for deep gases that consider trap types, depth, and reservoir quantification are needed.

Funding of $4 million in FY 1986 is required to initiate these research activities.

RECOMMENDED DOE FY 1986 LONG-TERM GAS-RELATED RESEARCH PROGRAM (RENEWABLES)

	FY 1984 Appropriation	FY 1985 Appropriation	GRI FY 1986 Recommendation
Biomass	$13.0M	$17.0M	$18.0M

In addition to SNG from coal, low-cost, nonpolluting, and renewable gas supplies from biomass could be made economically available in the future with the application of engineering and agricultural sciences to the development of methane-from-biomass systems. In particular, the cost of methane from biomass could be reduced, and the biomass resource base could be expanded by the development of highly efficient systems.

The unique advantages of biomass make it an excellent candidate for many regions of the U.S. that lack conventional energy resources. GRI began a program with the University of Florida's Institute of Food and Agricultural Sciences in 1982. GRI has other related programs in the Northeast with the New York Gas Group and the New York State Energy Research and Development Authority and in the Southwest with Texas A&M University. All of these are cofunded efforts. We anticipate that many of the results are transferrable to other parts of the country. DOE should expand the regional biomass concept by providing $4 million in the FY 1986 budget.

In terms of DOE-supported research, it should be centered on biotechnological advances that permit the manipulation of both the feedstock and the microorganisms used in the bioconversion process. Thus, using technically proven methods of cloning for infusion of genetic material into living cells, for the ability to fix nitrogen, and for a specific conversion process, one can simultaneously adapt the biological organisms of the conversion process to produce a more efficient system. With improved biomass feedstocks through bioengineering and other techniques, a cost-competitive energy system should begin to emerge.

The gas industry recommends that $12.5 million (including $4.0 million for regional programs) be used for biomass conversion; $1.5 million, for waste conversion technology; and $4 million, for research on biomass growth and harvesting.

SUMMARY

A consistent federal energy policy that provides adequate funding for long-term gas research in DOE's Fossil and Renewables programs is needed in order to insure affordable domestic natural gas supplies in the future. The gas industry recommends a DOE FY 1986 budget for gas-related research of $156 million consisting of a $35 million redirection in the DOE Office of Energy Research programs for hydrocarbon geosciences research. This recommendation essentially continues the programs approved by Congress for gas-related research over the past four years.

This completes my testimony. I will be happy to respond to any questions the Members may have.

Table 1
RECOMMENDED FY 1986 DOE GAS-RELATED RESEARCH BUDGET
($ Millions)

ADVANCED RESEARCH & TECHNOLOGY DEVELOPMENT	$ 13.5
Advanced gasification processes, fuel cells, materials and components, environmental analysis, instrumentation, coal utilization.	
COAL GASIFICATION	40.5
Advanced concepts, pressurized fluidized bed ash agglomerating PDU, Great Plains, gasification mechanisms, coal ash studies, coal conversion facility.	
UNDERGROUND COAL GASIFICATION	8.0
CRIP, Eastern coals, laboratory support, environmental.	
UNCONVENTIONAL GAS	35.0
Tight sands (lenticular), Devonian shale, coal seam methane, deep source gas.*	
FUEL CELLS	23.0
Onsite phosphoric acid technology development, molten carbonate, solid oxide.	
EASTERN OIL SHALE GASIFICATION	2.0
BIOMASS	18.0
Growth, harvesting, conversion, waste conversion, regional programs	
GEOPRESSURED RESOURCES*	16.0
Well data interpretation, coproduction, environmental	
TOTAL	$156.0

*Redirection in DOE General Science Program

Table 2
CONGRESSIONAL APPROPRIATIONS FOR DOE GAS-RELATED RESEARCH
($ Millions)

	FY 1982	FY 1983	FY 1984	FY 1985	Admin Req FY 1986
FOSSIL ENERGY					
Advanced Research and Technology Development (Gas-Related)	$ 12.50	$ 7.40	$ 12.00	$ 15.10	$ 7.17
Surface Coal Gasification	53.10	39.00	36.80	31.99	11.53
Underground Coal Gasification	8.30	6.00	6.00	5.76	4.26
Unconventional Gas Resources	8.70	13.90	13.50	10.24	8.87
Fuel Cells (Gas Related)	5.60	14.00	16.20	17.82	9.34
Eastern Oil Shale Gasification				2.00	0.00
LNG Safety	6.30	3.50	3.25	2.00	1.75
Naval Oil Shale #3				0.36	0.00
Subtotal	94.50	83.80	87.75	85.27	42.92
GEOPRESSURED METHANE	17.30	8.40	7.00	5.50	3.60
BIOMASS	3.00	4.00	13.00	17.00	10.00
TOTAL	$114.80	$ 96.20	$107.75	$107.77	56.52

Table 3
OFFICE OF ENERGY RESEARCH BUDGET*
($ Millions)

	FY 1984 Appropriations	FY 1985 Estimate	FY 1986 Request
High Energy & Nuclear Physics	$ 638.2	$ 727.8	$ 683.0
Fusion Energy	470.8	437.0	390.0
Basic Energy Sciences	337.3	422.6	409.8
Biological & Environmental Research	184.0	190.5	186.3
Advisory Assessment & Support	54.5	52.4	68.1
TOTAL	$1,684.8	$1,830.3	$1,737.2

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*Excludes advisory and oversight program direction and policy management.

Mr. FUQUA. We've already got permission for the statements to be made part of the record.

Mr. Mannella.

STATEMENT OF GENE MANNELLA, DEPUTY DIRECTOR, WASHINGTON OFFICE, ELECTRIC POWER RESEARCH INSTITUTE, WASHINGTON, DC

Mr. MANNELLA. EPRI's written statement today was prepared by Kurt Yeager, who is vice president of our coal combustion systems division. He could not make it here today because of a schedule conflict. I would like to have his statement submitted for the record in its entirety and give a brief summary myself.

We appreciate this invitation to meet with you today to discuss promising clean coal technologies and the DOE fossil energy program for fiscal year 1986. EPRI, as you know, is about 12 years old. It was established by the Nation's utilities to put together and implement a program in electric power generation, transmission, distribution, and utilization. We have over 500 member companies which include investor-owned, publically-owned, and cooperatively-owned utilities which represent about 70 percent of the generating capacity of the United States.

Over the next 5 years, EPRI will direct over $580 million to improving coal utilization and because of this commitment, this opportunity to appear before you today is very important to us. I would like to comment very briefly on the overall need for clean coal technology from the perspective of an industry that consumes about 80 percent of the coal used in the United States, and also from the perspective of the organization that must anticipate the needs of the industry and insure the availability of suitable technical options.

We have in the United States, looking at nameplate capacity, about 720,000 megawatts of peak generating capacity either installed or under construction. This we calculate would be sufficient to support about a 1.5-percent-per-year average growth in electricity demand between now and the end of the century. Now 1.5 percent is a historically low number and each percentage increase in demand growth rate would require about 100,000 megawatts of additional generating capacity over the remainder of the century. That's about 100 large generating stations. Therefore, we see the need very clearly for new options which can meet increasingly stringent siting and environmental demands and can be rapidly constructed in modular fashion over the range of unit sizes that would be in demand.

Coping with this need will require an intensive partnership commitment on the part of the utility industry, its suppliers, and government. In other words, to the extent that it is the desire of the Federal Government to reduce risk and hasten the introduction of new environmentally sound and economically promising technologies, there will be plenty of opportunity for constructive involvement in the coming decade.

EPRI has a well developed plan for fossil energy R&D which is proceeding as rapidly as funds permit. EPRI funding for clean coal research, development, and demonstration during the period 1985 to 1989 will encompass programs in environmental assessment, performance improvement advanced technology, coal quality, emission and effluent treatment, fluidized bed combustion, and coal conversion adding up to the number I gave you previously of $580 million, which I might point out, represents about one-third of the Institute's planned budget over the next 5 years and is in addition to the over $500 million already spent by EPRI in these R&D programs.

I would like to turn briefly to some of the issues that face the private sector because it is important to understand that they are different for the electric utility industry than other industries. This bears heavily on how to arrive at a constructive program for producing and applying new technology. Probably the single most important difference is that electric utilities are economically regulated and that the rates of return are governed by public utility commissions and profits do not necessarily reflect risks. Simply put, this means that risk and reward are very different for a utility than for a nonregulated company and this means that we need to develop a somewhat innovative approach for the appropriate government role.

There are a number of other areas where the utilities differ from nonregulated companies, such as tax credits, the way that they raise capital, the way that they handle financial risks. For example, incorporation of a new technology in a complex electric power system does entail risk even if someone else pays for the hardware. Just simply operating the system on the grid does include a considerable amount of risk. We are also concerned by the fact that foreign countries are becoming increasingly aggressive in the development of electrical technology and we fear the loss of technological leadership may force the utility industry and its suppliers to depend on foreign sources. Unfortunately, the adverse consequences of this are not clearly perceived because we really lack a reliable economic model. The impact that we've seen recently in other heavy industry strikes close enough to home to be worrisome.

Technology options are needed and some are available but they will take time to develop. One of our collective problems, that is the private sector as well as the Government, is trying to divine what will be needed by what timeframe and having that particular technical option ready to go.

Let me briefly touch on one issue that is real and representative of the challenge that confronts us. We've done analysis of various proposed acid rain control legislation and we feel that the thrust of this legislation would require scrubbers on about 100,000 megawatts of existing high sulfur coal fired generating capacity and would cost the Nation about $200 billion over the remaining life of the affected plants. Obviously, if the $200 billion necessary to implement the scrubber retrofit strategy were instead invested in plants using advanced coal technologies, it would provide about half of the new generating capacity the Nation is expected to require over the next 30 years. I think that's a very profound observation.

Therefore, we see that in a national coal utilization program, there has to be four major goals or objectives. We need a sound scientific base and increasingly we look to DOE for this. We need to demonstrate an array of potentially more effective retrofitable emission control alternatives than scrubbers as I mentioned above. We need to demonstrate the advanced coal utilizations technologies such as fluidized bed, pressurized fluidized bed, and others that are under study. We need to establish incentives to encourage commercialization.

I'd like to take just a few minutes to make a point regarding the funding of fossil energy R&D by the Federal Government. We are here today to discuss the adequacy of the DOE Fossil Energy Program budget request for fiscal year 1986. At the same time, we are mindful and we have heard much this morning that there has been recently a significant response to a program opportunity notice put forth by DOE in response to a congressional initiative. I think it is very important to view these two activities in their proper light and not to confuse them.

The goal of the ongoing DOE program as enunciated many times in recent years, is to undertake long-term, high-risk, and high-payoff research and development. The successful outcome of these efforts would presumably be available for various private sector initiatives to advance the respective technology to eventual commercialization. Therefore, our comments and recommendations on the DOE budget request speak to this role; that is, the adequacy of funding and the degree to which the programs complement ours as seen from the perspective of the electric power industry.

The proposed national clean coal program should not, in our opinion, be seen as a substitute or a surrogate for the ongoing DOE program. As we view it, the national clean coal program seeks to address a shortcoming that many of us have been distressed over; namely, that if the Federal Government confines itself to a basic research role, the road to commercialization will be difficult indeed, at least with regard to emerging clean coal technologies.

Since 80 percent of the coal used in the United States is for electric power production, and since electric utilities are economically regulated, the normal laissez-faire incentives to demonstrate new technologies on near commercial scales are lacking. Without Federal support at this level to absorb some of the risks, commercial development simply cannot keep pace with other demands such as environmental concern and economic growth.

While the subject of the hearing today is the DOE R&D budget, the possibility of a national clean coal program is on everybody's mind. Both of these programs are necessary and important. Let us keep in mind that they address two different portions of the research, development, and demonstration commercialization cycle.

With regard to the overall budget request, EPRI is mindful of the efforts of the Congress and the administration to control the deficit. However, we also feel it is incumbent to, as a major funder of energy R&D, to recommend levels of support consistent with our perception as to the future needs. Given the fact that coal will undoubtedly be the fuel of choice for the majority of the electric power generation for the remainder of the century, an fiscal year 1986 fossil budget of at least the level appropriated by Congress in fiscal year 1985 appears prudent. For details on the appropriate level for individual programs and technologies, we would defer to other various industry groups such as the fuel cell users group which will also present testimony today. The private sector will do its share and more in bringing needed technologies to the marketplace. As indicated earlier, EPRI is pledging $580 million over the next 5 years in clean coal technology alone.

Individual utilities will likely expend a similar amount as hosts or partners in a variety of projects. It is imperative that the Federal sector sustain both a meaningful basic technology program through the ongoing DOE activities, as well as the key role envisioned in the national clean coal program.

Mr. Chairman, that concludes my summary statement. I will be pleased to answer any questions you or the members might have.

[The prepared statement of Mr. Yeager follows:]

STATEMENT OF

KURT E. YEAGER
VICE PRESIDENT, COAL COMBUSTION SYSTEMS DIVISION
ELECTRIC POWER RESEARCN INSTITUTE

BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MARCH 6, 1985

Introductory Statement

Mr. Chairman, Members of the Subcommittee:

I am Kurt E. Yeager, Vice President and Director of the Coal Combustion Systems Division of the Electric Power Research Institute (EPRI). I appreciate this invitation to meet with you to discuss promising clean coal technologies and opportunities for their accelerated development and application. These opportunities have significant implications for the electric utility industry and therefore are of great importance to EPRI.

The Electric Power Research Institute was established by the Electric Utility Industry in 1972 to conduct a broad research and development program for the entire electric utility industry and its rate payers. EPRI's R&D mission is to develop new and improved technologies for electric power production, delivery and use, and to help accelerate their availability to insure an adequate supply of economic, reliable and environmentally acceptable electricity.

EPRI is supported by voluntary contributions from investor-owned, government-owned and cooperatively-owned electric utilities across the nation. Over the next five years, EPRI will direct over $580 million to improving coal utilization. This commitment is based on the premise that coal utilization and environmental protection are mutually compatible and that improved technology is the key to compatibility. Sound scientific data derived from independent, peer-reviewed research must be developed in a timely manner on topics of environmental concern. In addition, more information is needed to apply the potentially most cost-effective approaches to control emissions from power plants.

Current environmental control capabilities must also be improved by reducing capital and operating costs and preserving overall plant productivity. The importance of this effort is underscored by the fact that approximately 40% of the capital investment and 30% of the total cost of power for new, coal-fired power plants are related to environmental control. This includes sulfur dioxide (SO_2) scrubbing, particulate control, solid waste disposal, water treatment and plant cooling. These controls in their current form have a major impact on plant efficiency and reliability. Closely associated with this issue is the increasing difficulty in siting new utility and other energy facilities.

Since its inception, EPRI has worked with the Department of Energy (DOE and its predecessor agencies), the Environmental Protection Agency, and other Federal agencies with energy research and development responsibilities to achieve mutual technical objectives. In the spirit of that long-standing cooperation, EPRI and others recommend an accelerated national program to better understand the environmental issues constraining the use of coal and to develop, demonstrate and promptly apply improved, clean coal technology. This effort would build on activities already underway within the Federal and private sectors. The November 1984 DOE solicitation for opportunities in emerging clean coal technologies is reflective of this recommendation.

The Need for Technology

The coming decades will represent a major challenge to the nation's electricity supply capability which increasingly depends on coal utilization. The ability to meet this challenge will depend on technological improvement. For example, the 720,000 MW of peak generating capacity currently installed or under construction, is only sufficient to support about 1.5% per year average growth rate in electricity demand between now and the end of the century. Each percent increase in demand growth rate would require about 100,000 MW of additional generating capability over the remainder of the century. This requirement is likely to be increased by other uncertainties including additional environmental legislation, further nuclear deferments, oil supply interruption and the, as yet, unproven ability to concurrently increase both the availability and life of existing capacity. A successful industry strategy to meet this challenge will require technology for increased productivity from existing capacity, for conservation and end use management, and for additional generation capability.

On the supply side, fossil generating technology has not advanced appreciably over the past 30 years. Over this period emphasis has been instead on taking advantage of the economy of scale with average unit size increasing by about a factor of five. Although this was practical during the period of rapid electricity demand growth, these conditions are unlikely to apply again for most utilities in the foreseeable future.

Based on these changing realities, the utility industry stands at a threshold of fundamental change in its technological base for power generation. The present commercial technology is nearing the end of its development potential and is increasingly hard-pressed to respond to the rapidly changing requirements being placed on the industry. New options which can meet increasingly stringent siting and environmental demands and can be rapidly constructed in modular fashion over the range of unit sizes are particularly in demand. The next 10 years will therefore be of paramount importance, both in assuring future electricity supply and in controlling cost. Coping with this transition will require an intensive partnership commitment on the part of the utility industry, its suppliers, and government.

For EPRI and the utility industry, this means accelerating our already substantial R&D effort in environmental assessment and clean coal technology. For example, EPRI funding for clean coal research development and demonstration during the period 1985-1989 will encompass the following programs:

	1985-1989 EPRI Expenditures $(10^6\$)$
Environmental Assessment	78
Performance and Advanced Technology	41
Coal Quality	43
Emission & Effluent Treatment	129
Fluidized Bed Combustion	127
Coal Conversion	164
	582

This represents one-third of the Institute's planned budget over the next five years and is in addition to the over $500 million already spent by EPRI on these R&D programs.

EPRI has been pleased to be both a partner and a catalyst over the past decade to accelerate the development of clean coal technology. An important question which must be resolved before large scale application of these options can proceed is proof of their long term reliability under utility operating conditions. The EPRI program, therefore, stresses the demonstration of these options at sufficiently large scale to verify their commercial reliability. In the case of atmospheric fluid bed combustion and coal gasification, joint private/Federal efforts with EPRI have culminated in the necesary commercial demonstrations as indicated by the Cool Water gasification combined cycle project and the three AFBC demonstrations with TVA, Duke Power and the State of Kentucky; Northern States Power; and Colorado-Ute Rural Electric Cooperative. It is the major Federal participation with the private sector during development and prototype testing which has provided the confidence for these demonstrations to proceed under private sector initiative. Sustained Federal participation in both Cool Water and the TVA AFBC demonstration has also been crucial to the prompt implementation of these pioneer projects.

Unfortunately, no mechanism has been established to extend this demonstration initiative to other deserving clean coal technologies. As a result, opportunities in coal cleaning, pressurized fluidized bed combustion and other combustion improvements as well as environmental control technology are constrained from application. All of these opportunities can have a fundamental impact on the quantity and quality of coal utilization over the next 20 to 30 years.

Issues Facing the Private Sector

the role of the private sector in carrying out this R&D must consider the unique aspects of the primary using industry-the electric utilities, and their technology suppliers:

- The electric utility industry is a financially stressed, regulated industry. Rates of return are governed by public utility commissions, and therefore, profits do not necessarily reflect risks.

- Energy tax credits for new technology, permitted by other industries, are not available to electric utilities. This is at a time when the utility industry must assume a growing leadership for the development of its essential technological improvements. Contrary to popular conception, the utility industry is one of the most technologically intensive and it is technology which must solve the difficult demands of the future.

- Financial problems facing the industry and its inability to generate capital funds for improvement or expansion makes additional R&D funding even more difficult. As a result, EPRI is able to fund less than half the scope of its program at a time when the needs are increasing dramatically.

- Major financial risk is associated with incorporation of innovative technology into an established and complex electric power system so that it is economical and reliable.

- Utility supplier forms cannot be assured of a sufficient return on R&D investment to maintain technical leadership in the current limited domestic market situation. R&D is only the first step in a project which, if successful, will require time and orders of magnitude greater expenditures for engineering, manufacturing, marketing and capital before a profit is realized. The possibility of changes in government policies over the period further amplifies the risk.

- Foreign countries, where a more cooperative partnership between government and indestry exists, are aggressively moving to assume leadership in the development and commercialization of improved coal utilization technology.

- Loss of technological leadership may force the utility industry and its suppliers to depend on these foreign sources. Other, far-reaching implications for supplier confidence and the U.S. international position are self-evident in such foreign dependence.

Taken together, these circumstances continue to pose a problem of major proportions - a problem which should be of national concern. It becomes especially critical when it is necessary to build large-scale demonstrations. These are essential elements in proving out the reliability, economics and technical capability of new technologies. It is also often necessary to gain experience with several such large-scale projects before the risks are reduced to the level of broad commercial acceptability, especially in the utility industry where reliability of service must take first priority. Thus, there are a number of programs in coal utilization related technology for which the funding mechanism to achieve prompt development and application is not evident. These are necessary to resolve the issues constraining coal use today and for the foreseeable future.

The rate of market penetration of these new coal utilization options would also be enhanced by the development of regulatory and economic incentives which encourage introduction of innovative technology. Particularly important is the development of a quantitative basis for regulation, plus incentives to offset any operational uncertainties associated with new power generation technology. These economic incentives could include making exempt, pollution control bonds available for any clean, coal utilization technology. Other economic instruments encouraging the use of such processes might include accelerated depreciation treatment and enhanced tax credits or bond guarantees.

Technology Options

The inefficiencies and costs of current flue gas desulfurization technology coupled with the uncertain possibility that existing plants may require retrofitting of emission control leads to the need for additional, simplified emission control options. these range from improved physical coal clraning to low NO_x combustion, furnace sorbent injection, and dry scrubbing. No single one of these options will satisfy the widely varying conditions in the range of existing coal-fired utility and industrial power plants. As a set, however, they can reduce the cost and productivity limitations of emission control today.

Selection will depend on a number of variables including control requirements, cost and functional criteria such as plant design and space limitations. This third category can be a particularly important constraint when considering retrofit to existing plants. Unlike new plants where the boiler and emission conttols can be designed as an integrated unit, retrofit requires adaptation to a plant not designed for such modification. This can lead to compromise and additional expense.

The more effective alternative is the use of new coal utilization technologies such as fluidized bed combustion (FBC) or gasification combined cycle (GCC). These technologies combine emission control within the combustion or conversion process. The result is both greater emission control efficiency and improved generation productivity to fundamentally resolve perceived conflicts between energy and the environment. This underscores the value of economic and regulatory incentives that encourage prompt transition to these improved coal utilization options.

The principal appeal of these technologies is that they directly address the major factors affecting coal-fired power generation - notably, emission control. Combining emission control with the combustion or conversion process is inherently less costly and more efficient than removing pollutants from the flue gas. As a result, they are a more effective alternative for an industry facing the possibility of mandated additions of flue gas desulfurization systems to current coal-fired capacity.

For example, proposed acid rain control legislation that would retrofit flue gas scrubbers on up to 100,000 MW of existing, high sulfur coal-fired generating capacity would cost the nation $200 billion over the remaining life of the affected plants. A more effective alternative would be introduction of new, clean coal technologies that offer greater emission control efficiency and improved generation productivity. If the $200 billion necessary to implement the scrubber retrofit strategy were instead invested on plants using advanced coal technologies, it would provide about half of the new generating capacity the nation is likely to require over the next 30 years. Such an investment would at the same time provide superior environmental control, not only for sulfur oxides but for nitrogen oxides and solid waste as well, while also improving the productivity and cost of power generation.

The most effective national coal utilization program therefore should have four major objectives. Based on the existing development foundation, all four objectives can be achieved within the next five years. It will require, however, a major, joint private/Federal effort to share the costs and risks, particularly at the technology demonstration scale.

a. Establish a sounder scientific base to guide the nation on the needs and appropriate timing of emission controls.

b. Demonstrate the array of potentially more effective retrofittable emission control alternatives to current flue gas desulfurization (scrubber) technology.

c. Demonstrate the advanced coal utilization technologies, e.g. atmospheric fluidized bed combustion, pressurized fluidized bed combustion, and gasification combined cycle, over a sufficient range of conditions to establish performance, cost, and reliability.

d. Establish incentives to encourage the prompt commercial implementation of these technologies.

In order to meet these objectives, the utility industry, its suppliers, and EPRI, have therefore proposed $2 billion in joint projects to DOE with 60% of the funding from the private sector. These are in response to the November 1984, DOE program announcement on emerging clean coal technologies.

These proposed projects are remarkably consistent in scope and cost estimate with the independent recomendations of the DOE's Energy Research Advisory Board (ERAB) Panel on Clean Coal Use Technologies which encourages expanded DOE participation in coal technology development and demonstration. These projects reflect both the broad scope of opportunities to expand improved coal utilization and the major investment which the utility industry and its suppliers are prepared to make in developing and demonstrating these improvements. The Appendix describes these opportunities in more detail.

The Role of DOE

Review of the DOE Fossil Energy budget indicates that only about 30% of the total coal program is devoted to the clean combustion of coal. Yet, direct combustion will continue to dominate the use of coal for the rest of the century, and beyond. Thus, an in-balance exists between the several coal users and the related R&D budgets. This is quite apart from the major in-balance between R&D aimed at fossil versus nuclear energy, if these are compared to their predicted contribution for electric power generation.

The best criterion for the distribution of R&D funds will be the "marketplace"; i.e., the willingness for private sector cofunding, particularly cofunding by the techology user. The Appendix discusses a number of these "marketplace" opportunities which are proposed by the private sector. DOE cannot pursue all promising areas and thus priorities must be set. In this context the private sector should be more involved in the decision-making process.

The total amount budgeted by DOE for FY 1986 in the field of Clean Use of Coal is about $57 million. This continuing budget decline is inconsistent with the needs which the increasing use of coal implies. Within the Clean Use of Coal area, the overall DOE program is only able to touch on most relevant technical areas. Most critically, the budget does not allow DOE to aid in the transfer of the new technologies to the private sector nor to assure their prompt commercialization. Specifically, as recommended by DOE's ERAB Clean Coal Use Technology Panel, DOE should participate in the needed demonstrations which are characteristic for utility acceptance of new technology. Obviously, careful selection of projects and extensive private cofunding are prerequisites.

Clean coal technology areas where increased DOE participation is particularly needed include:

- Coal quality improvement and reserve assessment
- Combustion diagnostics
- Low NO_x combustion systems
- Furnace Sorbent Injection (LIMB)
- Coal-water slurries
- Flue gas desulfurization
- Circulating atmospheric fluidized bed combustion
- Pressurized fluidized combustion
- Coal liquefaction (Wilsonville)
- Gasification/combined cycle power generation
- Once through methanol coproduction
- Gasification-fuel cell power generation
- Environmental impact mitigation

These opportunities are discussed in the Appendix.

DOE has a unique opportunity to work closely with the private sector to resolve the various constraints, often resulting from governmental action, on the nation's use of coal. In the context, cofunding is only one way in which DOE can help. DOE should also lead, when opportunities arise, in urging use of tax incentives which could result in increased private sector R&D efforts and reduce the need for direct DOE involvement.

Finally, leadership also calls for stability of program and purpose, especially where cofunding is involved. A prime concern of private sector R&D management is that program direction and budget, once adopted, will not be changed arbitrarily. This is particularly important to multi-year, larger projects where change in direction is costly and wasteful. Improved stability would facilitate commercialization of improved coal technology.

Conclusions

The nation stands at a threshold of fundamental change in its technological base for coal-fired power generation. The present commnercial technology is nearing the end of its development potential and is increasingly hard pressed to respond to the rapidly changing requirements being placed on the industry. An accelerated, two-pronged approach is necessary: first, promptly transfer improved coal technology from development to application and second, extract the last measure of performance from the existing generation base necessary to span this transition period. Coping with this transition will require an intensive, joint commitment over the next 5 to 10 years on the part of industry and government.

The actions of the Federal government in direct support of energy related research, development and demonstration, and in the form of incentives, have a profound effect on the private sector's ability to develop and utilize clean coal technology. Federal programs need to consider the underlying circumstances affecting private industry and the importance of electric energy and coal to the nation's economy and security needs. The rate of commercialization and use of improved technology also depends on legislative and regulatory incentives. Too often our dependence on the adversarial approach makes the uncertainties and conflicts restricting coal use more severe and disruptive than necessary and restricts the introduction of technological improvements.

There is no shortage of opportunities to improve the efficiency, reliability and environmental performance of emerging clean coal technologies. We are learning how to produce power cleanly from coal in a variety of forms meeting the demands of the diverse national energy system. The question is whether we can reduce this knowledge to practice in a period when both regulatory uncertainty and financial disincentives constrain the effort. The problem affects all phases of the development cycle, but is greatest in the financially intensive large pilot and demonstration steps necessary for commercial confidence. The federal clean coal initiative, jointly implemented with industry support, can substantially enhance the nation's ability to commercialize the many developments in clean coal technology. EPRI is prepared to do its part in formulating and implementing these efforts, including the investment of $580 million over the next five years alone.

Appendix

EMERGING CLEAN COAL TECHNOLOGIES

An enhanced Clean Coal research, development and demonstration program represents an important need because of the nation's limited ability to transfer potentially superior coal utilization technology into commerical application. The present lack of an adequate funding mechanism to build the facilities necessary to demonstrate the reliability, economics and performance of new coal technology is a source of national concern. While private sector efforts have been maintained, they are insufficient in the face of declining incentives for additional private investment. As a result, there are a number of key coal based technologies where the funding to achieve prompt demonstration and commercialization is not evident. This may have profound consequences for the 1990's when new electric generating demands, which must rely on coal, collide with the growing environmental ethic of our society. Emerging clean coal technology that can benefit by an accelerated Federal and private sector initiative are described below.

1. Coal Quality Improvement

EPRI has constructed a 20 ton per hour coal cleaning test facility (CCTF). As a first priority, additional resources should be directed to increasing the scope of the joint DOE/EPRI advanced coal cleaning development project which will use the CCTF to test various advanced physical and chemical cleaning processes. These additional resources would both accelerate the availability of results and assure large scale testing of a broader range of cleaning processes. Additional priority coal quality objectives should also include:

- More efficient and economical fine coal cleaning and recovery techniques.
- Techniques for improving the slagging and fouling characteristics of lower rank coals.
- More economical chemical cleaning techniques providing thorough sulfur and ash removal.
- Improved sampling and analytical procedures to insure confidence in coal reserve quantity and quality estimates.
- Automated cleaning process control and on-line continuous measurement techniques to improve reliability and increase quality.

Over one hundred million dollars in specific cost shared projects addressing these issues have been proposed to the utility industry and it suppliers.

2. Combustion Technology

a. Combustion diagnostics and effect on power plant performance.

Areas requiring additional effort include:

- Characterization of coal ash chemistry and its effect on combustion.
- Standardization of slagging indices.
- Effect of coal particle size on fouling/slagging.
- Effect of coal variability on power plant performance.

Achievement of these objectives, which may be further accentuated if coal cleaning and switching are increased to meet emission control requirements, will first require expanded combustion testing facilities. These should include a 100 million Btu/hr facility whose results could be directly extrapolated to commercial scale furnaces and boilers. It is also essential that the smaller facilities be instrumented to measure the transient chemical and physical parameters throughout the combustion process as well as the properties of the resulting gaseous and particulate products. This capability could, for example, apply state-of-the-art measurement techniques developed with DOE support at the Sandia Combustion Facility. It might be most effectively implemented in conjunction with a stable university research program to achieve much needed national centers of excellence in coal science.

b. Low NOx Combustion Systems

This too is an area of importance where DOE is not currently involved. DOE is exploring flue gas cleaning systems to remove NOx, however, the NOx issue requires accelerated attention in the near term by development of modified burners which offer substantial NOx reduction (50-75%). Low-NOx burner designs are nearing demonstration scale development by the several U.S. boiler manufacturers. While it appears that many coal fired utility boilers could be retrofitted with low-NOx burners, the different flame shape and the specific geometric and mechanical requirements can represent significant changes from existing equipment. The boiler engineering/operational impacts also must be addressed through large scale demonstration tests.

Advanced NOx combustion control concepts are also being developed to more closely control the fuel/air mixing, temperature, and combustion chemistry in the furnace. Much of this development has taken place to date in Japan. These "reburning" or overfiring techniques which may produce a further 50% in NOx emissions relative to low NOx burners, should also receive increased development and demonstration attention.

c. Furnace Sorbent Injection

Retrofit demonstrations of in-boiler sulfur control technology should be emphasized as a relatively low cost, near-term approach to reducing SO_2 emissions from existing boilers. The research projects conducted to date have laid the groundwork for prototype tests at a number of utility boilers in the 50-150 MWe size range. These prototype tests are an integral part of the development process and are necessary to provide confidence for commercial application. The issue here is the impact on the performance and reliability of the boiler and particulate control system, not just SO_2 removal efficiency.

We have identified at least seven utility companies that are interested in participating in this prototype effort, including financial support and hosting the tests. We estimate that four prototypes will be necessary to qualify the limestone injection technology over the range of desired boilers and coal conditions.

Unfortunately the development of this technology is limited by the lack of funding necessary to implement these planned prototypes. Less than half the approximately $60 million necessary to develop and demonstrate this technology over the next few years is budgeted by the Federal and private sectors.

d. Coal-Water Slurry

The retrofit of an oil-fired boiler of at least 100 MWe using clean coal is a valuable objective and should focus on the use of coal-water slurry (CWS) in a boiler originally designed for oil. The slurrying of deeply cleaned coals aids the total cleaning process and enhances its handling and storability in the fuel system associated with oil-fired plants. Eighteen utilities are now participating with EPRI in the engineering evaluation of alternative sites for such a demonstration. Such a demonstration could be performed by 1986, if sufficient CWS production capacity can be established. A demonstration in the 400 MWe size range would be particularly advantageous if price guarantees or other support necessary to achieve production of about 1 million tons per year can be provided. To assure the technical foundation of such a large scale CWS application, further R&D attention should also be given to:

- Development of more reliable CWS burners
- Development of erosion resistant convection pass tubine materials.

This would logically complement EPRI and DOE efforts involving slurry characterization, development of utilization guidelines, and testing of slurry handling, pumping and firing equipment. From a regulatory standpoint, it is essential that boilers converting to deeply cleaned coal in any form be permitted to meet their existing emission requirements and not be forced to meet New Source Performance Standards (NSPS). Otherwise, commercial acceptance will be minimal.

3. Fluidized Bed Combustion

a. Atmospheric Fluidized Bed Combustion

Development of Atmospheric Fluidized Bed Combustion (AFB) has successfully progressed from the process confirmation stage to engineering prototype, making commercial scale utility application possible this decade. AFB has become an important boiler alternative because it is an evolutionary improvement in coal utilization, better meeting the requirements of the 1990's. The capabilities which excite this interest include: (a) less sensitivity to fuel quality, thus permitting users to operate more in a "buyers" fuel market; (b) ability to control SO_2 and NOx within the combustion process; and (c) less cost sensitivity to unit size.

The success of these efforts provides the technical basis for 100-200 MW commercial demonstrations by the utility industry that will be operational this decade. Three such complementary utility demonstrations at TVA, Colorado-Ute Electric Association and Northern States Power Company are now being implemented with $350 million in private sector funding.

In each case the utility industry will fund the largest share of these demonstrations with EPRI and the suppliers sharing the first-of-a-kind risk costs. The $30 million authorized for DOE participation in the TVA/Duke Power/State of Kentucky demonstration will be an important contribution to financial closure as soon as it becomes available to the project. Similar DOE participation in the demonstration of circulating AFB technology at Colorado-Ute is also encouraged. Table 1 further describes these pioneer utility AFBC demonstrations.

Although AFB is proceeding into commercial application, considerable opportunity for continued DOE support exists. Rather than concentrating on the investigation of advanced, proprietary AFBC concepts, this support should be directed toward considerations which pace its application such as the choice of generic materials, fuel characterization and environmental control. In addition special emphasis should be placed on the demonstration of circulating AFB in both industrial and utility applications.

Table 1. Pioneer Utility Fluidized-Bed Combustion Demonstrations

	TVA/Duke	NSP	Colorado-Ute
Location	Paducah, Ky.	Minneapolis, Minn.	Nucla, Colo.
Size, MW (e)	160	125	110
FBC type	bubbling	bubbling	circulating
Scope	add-on boiler	boiler conversion	add-on boiler & T/G
Coal	high S bituminous	low S subbituminous	low S, high ash bituminous
Start-up	1988	1986	1988
Steam conditions	reheat	no reheat	no reheat
Feed system	underbed	overbed	in-bed
Dust collector	baghouse	ESP	baghouse
Structural design	top support	top support & bottom support	top support
Dispatch schedule	base load, some cycling	2-shift, 5-day cycle	base load
Start-ups per year	20	250	<10
Boiler Supplier	Combustion Engineering	Foster Wheeler	Pyropower (Ahlstrom)

The continuity and success of the previous combined Federal/private development effort is making these pioneer AFB demonstrations possible primarily through private support. This provides a successful prototype for similar utility and government collaboration in other areas of coal utilization R&D.

b. Pressurized Fluidized Bed Combustion

The new and dynamic utility climate also influences pressurized fluidized bed combustion (PFB) development. The influence results from the trend toward smaller new unit size plus utility priority on uprating the capacity of existing units to bring generation on line quickly and at the lowest cost. These advantages can translate into an effective reduction in capital costs of $200/kW to $300/kW by better matching load growth and reducing the cost of work in progress (CWIP). PFB provides the opportunity to add these advantages to the inherent fuel flexibility and environmental control capabilities of atmospheric fluidized bed combustion.

As a result, development and demonstration emphasis should be placed on PFB turbocharged boilers which can provide shop-fabricated, barge transportable, steam generation modules. These may be rapidly field-erected to provide the desired uprating in unit sizes of 50 MWe to 250 MWe. This approach can also use coal to replace or increase the capacity of existing oil-to gas-fired plants while meeting stringent siting and environmental control constraints. It also provides the potential for lowest busbar energy cost in the 1990's.

By developing PFB in this low-risk configuration and demonstrating its feasibility in financially attractice repowering applications, sufficient confidence can be gained to increase the firing temperature in future plants to combined-cycle conditions. This evolutionary path can eventually lead to the 40%+ efficient, direct coal-fired, combined-cycle power plant.

The development effort today centers on the PFB boiler and involves the design base for the heat transfer tube bundle within the bed as well as coal feeding, ash handling, and control of the PFB boiler system. The only available facilities for resolution of these technical issues are the International Energy Agency (IEA) Grimethorpe PFB Pilot Facility and Supporting Coal Utilization Research Laboratory (CURL) in England. Unfortunately the Curtiss-Wright PFB pilot in Wood-Ridge, N.J. is now being dismantled by DOE before it can contribute to the development of this technology.

Tests are planned with two U.S. boiler manufacturers, Babcock & Wilcox and Foster Wheeler. In both cases, the manufacturers will design and supply heat transfer tube bundles for performance and reliability testing. These tests are a key stepping stone to implementing planned PFB demonstration projects with the utility industry. As a result of approximately a decade of federally funded research, PFB technology has now reached the proof-of-concept state of development where its advantages can be confirmed. Unfortunately, as this critical R&D threshold is reached, DOE support has been essentially terminated, thus stalling PFB's potential for commercial application in the U.S.

A major joint DOE/private initiative should therefore be mounted which consists of four primary elements: (a) supporting research on fluidization, materials and sorbent performance, (b) proof-of-concept testing at the Grimethrope facilities, (c) pilot scale development of circulating PFB, and (d) demonstrations of 100 MW PFB modules for both bubbling and circulating boiler designs. Such demonstrations, are technically feasible this decade and are proposed to DOE by an impressive range of utilities including Florida Power & Light, Wisconsin Electric, Public Service Electric & Gas, and American Electric Power, all in partnership with major boiler and turbine suppliers.

4. Flue Gas Desulfurization (FGD)

The highest priority should be placed on resolving the reliability, by-product disposal and cost issues impeding the effectiveness of flue gas desulfurization (FGD), especially for retrofit on existing coal-fired power plants. A variety of simplified and improved FGD processes have been developed by the private sector, such as the Chiyoda 121 Process, which should be demonstrated at the 100 -150 MWe scale as soon as possible. The effort should not, however, be limited to processes capable of 90% SO_2 removal. Simplified processes with somewhat lower removal efficiencies may be very useful in the event that retrofit control requirements develop.

Federal participation is also encouraged in the new EPRI High Sulfur Test Center being built to address the chemistry and materials issues limiting FGD performance and reliability. This could have, for example, a substantial impact on any acid rain control strategy requiring retrofittable FGD. The Center will consist of a series of scrubber pilot plants with supporting laboratories, all operating on high sulfur flue gas produced by a coal-fired utility boiler. EPRI and the utility industry have committed $12 million for the construction of this facility with an additional $25 million for operating costs.

A final area of flue gas cleaning requiring additional Federal attention is particulate control technology improvements. All of the technologies to reduce SO_2 emissions, from coal cleaning to scrubbers, will have a major impact on the quantity and quality of particulate matter to be collected. Present electrostatic precipitator technology lacks the flexibility to adapt to these new conditions without substantial losses in collection efficiency unless an intensive development and testing effort is initiated.

Consideration of a demonstration of a combined SOx/NOx removal system within the next five years is speculative. Although DOE is today supporting development of several such technologies including the Sulf-X and E-Beam processes, these are still at relatively small scale and a preliminary stage of development. They are unlikely to achieve sufficient performance or cost confidence within the near future to justify large prototype facilities. Increased funding for smaller pilot scale development would probably be more effective within this time frame.

5. Gasification Combined Cycle (GCC)

Coal gasification integrated with combustion turbine combined cycle power generation is an attractive new technology currently being demonstrated at Southern California Edison's Cool Water site near Daggett, California. This project employs a 1000 ton/day oxygen blown Texaco coal-water slurry fed entrained gasifier and a currently commercial General Electric Frame 7 gas turbine. The plant was built on schedule for $263 million representing a savings of over $31 million from the budget for the program. Since start up in May 1984 the plant has converted over 130,000 tons of Utah bituminous coal to clean gaseous fuel and generated 270 million KW hours of electricity. The Cool Water plant represents the cleanest coal based electricity generation based on the environmental measurements for emissions in the stack of the General Electric combined cycle equipment.

The Cool Water experience and other EPRI studies show that GCC plants based on this technology can be competitive and environmentally superior to other coal technologies. Major advantages are: (a) higher efficiency (b) lower emissions and (c) lower water and land requirements. Commercial plants in the 200-500 Mw range will comprise multiple trains of similar sized components (gasifiers, gas turbines) already demonstrated at Cool Water. These plants also may be installed in phases using modular shop fabricated components, thus enabling utilities to add capacity in a manner that better matches load growth without the extended construction periods and attendant financial exposure experienced with large conventional power plants. The multiple train configuration of such GCC plants should also result in high overall plant availability.

Another attractive opportunity for the introduction of GCC technology into the utility industry is to first install gas turbine or combined cycle capacity based on coventional oil and gas fuels and to add coal gasification later when either (a) base load demand has grown (b) conventional oil and gas fuel costs have risen unacceptably. This strategy is currently being investigated by EPRI and contractors with ten individual utilities for their specific systems.

EPRI is also planning to support the further development of other competing coal gasification processes such as the British Gas/Lurgi slagging gasifier. A program of test runs on U.S. bituminous coals is currently planned on a 600 ton/day British Gas/Lurgi gasifier in Scotland starting in 1985 under joint funding from EPRI, the Gas Research Institute and the British Gas Corporation.

The British Gas/Lurgi slagging moving bed gasification technology is particularly suited to the use of the abundant high sulfur bituminous Appalachian and Mid Western coals which are currently under utilized. The British Gas/Lurgi moving bed technology differs markedly from the Texaco entrained gasifier used at Cool Water and we believe offers certain advantages in efficiency and oxygen consumption. DOE and EPRI both participated in the earlier stages of development of the British Gas/Lurgi technology and formerly planned to proceed to a 'demonstration' plant. Accordingly EPRI believes that the next logical step for GCC technology development would be the demonstration of the British Gas/Lurgi slagging gasifier based on high sulfur Eastern or Mid Western coal. The value of such a project could be further markedly enhanced by the inclusion of high firing temperature more efficienct gas turbine in the plant configuration. Both DOE and EPRI have previously supported considerable work with gas turbine manufacturers on such improvements, which has now advanced to the stage where full scale implementation is justified.

A GCC project based on these technologies and concepts is currently being studied by EPRI, Detroit Edison and Consumers Power. A plant capacity in the 150-200 Mw range is contemplated.

GCC systems also offer attractive opportunities for the coproduction of other energy forms such as steam, Substitute Natural Gas (SNG) and methanol. The coproduction of methanol is of particular interest to utilities since it can provide a source of peaking fuel. The 'once-through' methanol concept which has been under development with DOE, EPRI and other private support is now ready for a larger scale test at a coal gasification site. The most logical and suitable location is a TVA's Ammonia from Coal project in Mussel Shoals, Alabama. Additional DOE support for this facility at TVA is strongly recommended to provide a test center for the above mentioned once through methanol concept.

6. Fuel Cell - Gasification

Fuel cells are modular, environmentally acceptable power plants that offer the most efficient use of petroleum and natural gas in the near-term and coal derived fuels in the longer-term.

Phosphoric acid fuel cells are expected to achieve commercial status by 1990. A market potential of 45,000MW is projected for the year 2000 with savings approaching 90×10^6 barrels of oil (equiv.) per year. The importance of this technology to the electric utility industry is described in separate testimony provided by the Fuel Cell Users Group of the Electric Utility Industry. Further evidence of the importance of phosphoric acid fuel cells to electric utilities is provided by the increased commitments of five Japanese and two U.S. manufacturers to large scale demonstration and commercial prototype projects.

However, the commercial success of phosphoric acid fuel cells is not assured and will depend upon continued technology improvements to achieve the reliability and the capital costs necessary to penetrate the market and achieve the projected benefits. The absence of any funding for phosphoric acid fuel cells in the Department's FY86 budget is alarming and ignores the needs of on-going programs as well as the progress being made under the coordinated support of DOE and EPRI. These efforts if sustained at current levels promise to achieve the targets while improving the power plant efficiency from the current 40% to as much as 47%. Beyond this, the integration of fuel cells with coal gasifiers need to be explored to confirm the projected coal to ac power efficiency of 37%. Interest in using phosphoric acid fuel cells with coal was emphasized by the submission of nine proposals in response to DOE's recent program announcements regarding emerging clean coal technologies. EPRI has bedgeted over $50 million to support the continued development and commercial introduction of phosphoric acid fuel cell power plants during the 1985-1989 time period.

EPRI also supports the longer-range molten carbonate and solid oxide fuel cel technologies. We feel that the Department's FY86 request for these technologies is adequate.

7. Advanced Coal Liquefaction

The Wilsonville Advanced Coal Liquefaction Research & Development Faciligy has made a significant contribution to advancing coal liquefaction technology. During 1985, EPRI will provide funds to add approximately $900,000 in capital improvements to the Wilsonville pilot plant. This new equipment will provide for the testing in FY'86 of new process configurations which may further improve the process efficiency, reduce capital cost, and provide a better understanding of this complex process. Current programs which are planned through 1986 would advance this technology to technical readiness for scale-up to commercial application. The Wilsonville program for FY'86 is not expected to produce a "breakthrough" which will allow direct coal liquefaction to compete with the current crude oil price of $25 to $30 per barrel. However, it is expected to produce a data base that can be used to design a two-stage process to produce a given product slate whenever economics or national commitments require. We currently estimate that distillate products would cost $45 to $55 per barrel (in 1984 dollars).

The major objectives can be reached by the end of 1986 and unless there is a drastic change in the nation's outlook for oil, the plans for Wilsonville will include completion of the facility at the end of 1986. $6.5 million in DOE participation in FY'86 is encouraged to permit achievement of these objectives.

The Wilsonville facility has become a unique national asset in that it has the broadest capability of any liquefaction pilot plant in the United States, is open for the testing of proprietary technology developed by others at a meaningful scale, and produces sufficient quantities of products for small-scale combustion testing and product upgrading research. The project has consistently operated within budget.

If the program is ended before the program goals have been completed, the data obtained to date will lose a significant part of their value. Currently the data are in the form of discrete points. These data cannot be used to predict what product slates can be expected from operation at conditions that were not tested. Modeling of individual process units is an essential step before the presently unrelated data can best be understood.

8. Environmental Assessment and Mitigation

Major benefits to coal utilization could be obtained by a substantial experiment in lake liming and a massive tracer investigation of the transport of SO_2.

In Sweden where a similar situation exists, a major national program is underway to mitigate acidification and introduce a fish stocking program. Currently, about $4 million per year is being spent to manage between 10,000 and 20,000 lakes. However, several questions remain.

Some ecologists are concerned as to possible secondary effects of using lime or limestone in surface waters. In the United States EPRI, in an over $3 million three year study entitled Lake Acidification Mitigation Project (LAMP), has initiated an investigation of the ecological consequence of neutralizing waters in three Adirondack lakes. Swedish investigators will provide data on a few of the lakes to compare with the EPRI derived data.

However, no systematic program for analyzing the costs and effectiveness of various mitigation systems has been started. Currently there are a number of options for delivery of the neutralizing material: by airplane, helicopter, truck, tanker, truck, boat, etc. Also, there are a number of substances which can be used to neutralize the water: lime, quick-lime, limestone, and, there exist a number of ways of delivering the materials: by single treatment in the water, by multiple treatments of the water, by treating the lake itself or by treating streams, the shoreline, or the entire watershed.

While a good deal of data exists from the Swedish experience and a little data from Canadian and U.S. experience, there is a need for a systematic cost and efficency assessment of mitigation alternatives in the U.S. A major experiment providing experience on 250-500 lakes could be performed for about $20 million.

If there were a decision to reduce emissions in order to reduce deposition in certain sensitive ecological areas, the current understanding of the atmospheric processes is not sufficiently developed to enable targeted options to be chosen. Whether nearby sources or distant sources are the most important contributors to acidic deposition in the sensitive areas makes a huge difference in the potential cost of a control program.

For example, if distant sources were the major contributor, to achieve a reduced deposition a general reduction in emissions would have to be used. On the other hand, if local sources were more important, a much more limited emissions control program would be possible. In analyses of such possible differences, it has been found that the cost of emissions control might be reduced by as much as a factor of ten if we only knew how to design such an efficient program.

EPRI has examined how this atmospheric information might be acquired. Current knowledge of atmospheric physics and chemistry and current modeling capability do not now provide enough information to accurately predict source-receptor relations. Nor do improvements in these areas of science over the next ten years seem likely to provide the accuracy needed.

However, EPA, NOAA, DOE and EPRI have experimented with utilizing tracers to obtain the needed source-receptor information. In addition, EPA has designed a small regional experiment while EPRI has designed an experiemnt to encompass the entire eastern one-half of the U.S. Currently, the identified major difficulties in implementing such an experiment are being studied. An experiment of this type would cost about $200 million and could be initiated in 1986.

DISCUSSION

Mr. Fuqua. Thank you, Mr. Mannella. I might point out on the subject you discussed, last year we held some hearings on the very subject of after you get to proof of concept, that it's absolutely imperative as a result of those hearings and the testimony that we received, that in most cases, it requires some help from Government in a matching program to take these to full commercialization. Many times, proof of concept is very small scale. Scale-up still has a lot of unknowns and there is an appropriate role for the Federal role to participate in trying to get some of these technologies commercialized so that lenders and investors will feel more comfortable in utilizing those advanced technologies.

David, in the discussion with Mr. Vaughan about the surface coal gasification and the commercialization process, what additional data do you see is necessary to be collected before that can become a commercial process?

Mr. Webb. Mr. Chairman, we think what really needs to happen in case of surface coal gasification is we need to demonstrate a sufficiently large-scale process that can convert Eastern coals efficiently and handle the agglomerating properties of Eastern coals, and processes that could also handle coal finds. What we have submitted in response to the clean coal initiatives was that to construct a test facility at an existing site, cofunded with industry, where you could test these advanced processes. They come out of industry or out of the DOE program at sizes from 600 to 1,000 tons. That would give you enough information from both the technical and an economic standpoint. Then those processes that can truly make advances in handling our Eastern coal and our coal fines, could be gradually integrated into the few coal gasification plants that will probably be built in the next 20 years using the fixed-bed technology that was developed in Germany. That's what we think has to happen if you're going to get processes integrated that can use advanced technology.

Mr. Fuqua. Mr. Baly, Mr. Lawrence of AGA recently commented that the 18-month gas bubble has now lasted 7 years. You indicated that their estimates of the amount that it could go as much as 60 years based on our current rate of consumption. How much longer past 60 years do you think that may persist? How do we justify research in the conversion of coal to synthetic natural gas when we have a 60-year supply available? Is it imperative we proceed today?

Mr. **Baly**. Yes sir, it is. The gas bubble that Mr. Lawrence referred to is the gas that excess supply that we could get and use today. The 60 years is sort of the resource base that reserves that you could get with today's technology and today's dollars. Due to lack of demand, the bubble that Mr. Lawrence cited, which everyone said had been 18 months for 7 years now, probably will last another couple of years. There are Federal laws that restrain the use of gas. No gas is allowed to be used in new industrial, new electric facilities, and that is certainly a hinderance. We did have the recession. New gas has only been decontrolled now for 2 months and so we are starting to see a free market work.

The increase in sales from 1983-84 is the biggest year-to-year increase in sales since 1969. Certainly, the incentives in Natural Gas Policy Act in 1978, which you and other colleagues supported, did encourage drilling for new gas. That, along with the lack of demand, did build up this bubble. We do see in several years, supply and demand coming into equilibrium. That's even more important that private industry has used its own funds to develop offshore drilling. When we look at geopressured; when we look at trying to control a geopressured well, not to bring the brine and the gas up together and get rid of the hot salt water, but try to control that blowout and let the gas flow naturally. It's those kinds of technologies with the Federal Government's help that down the road in the next 15 or 20 years, we're going to need to move on. I think it's because of the controls at the wellhead for gas that DOE and the others have focused more on control technology of burning coal than at looking at flame characteristics, emissions monitoring, and the dual use of gas with other fuels.

Mr. **Fuqua**. Mr. Boucher.

Mr. **Boucher**. Thank you, Mr. Chairman. Mr. Mannella, I am very interested in the work that's being done on coal-water slurries and their use in the place of oil in the boilers of industries and utilities with minor conversions. Can you give me some idea of the status of that substitution in electric utilities today and how long you think it's going to be before we see full commercialization of the use of coal-water slurries?

Mr. **Mannella**. I really can't give you any details unfortunately, Mr. Boucher. I'm not that familiar with the program. I do know that within the past year or so there have been some test burns and it is my understanding it continues to look promising and that there is a fair amount of activity. I will see if there is some additional information available and if it is, I'll send it to you personally.

Mr. **Boucher**. I would appreciate that. Let me ask also concerning the submission of proposals by your constituent members for approval and subsequent funding under the clean coal technology reserves. Are there proposals being submitted today by electric utilities for those projects?

Mr. **Mannella**. Indeed there are. What EPRI did was to have many conversations with people who were interested in responding to the program opportunity notice. In sort of a summary way, they produced a document which listed all of the conversations that we had had with potential proposers or responders. The sum total of which is that we are identified in programs that would total about $2 billion of which we would anticipate funding about one-third and individual utilities would also fund about one-third, leaving the way open for the Federal Government via the final third, to mount a very aggressive program.

Mr. **Boucher**. Thank you very much. I guess I'm chairing. Mr. Walgren.

Mr. **Walgren**. I had wanted to ask the representative from EPRI about the Homer City plan to conduct some clean coal projects in cleaning coal, and I heard Mr. Vaughan say that EPRI had taken on the responsibility to burn these coals once the cleaning process had been accomplished. Is that your understanding of that proposal and has a firm commitment been made?

Mr. **Mannella**. The Homer City facility is an EPRI facility and we have been conducting coal cleaning technology work there for a number of years. We entered into a cooperative agreement with the Department of Energy last fall because they had some new coal-cleaning technology that was very attractive and it looked like it would be a good deal for both sides. We had the facility and the equipment and they had the technology. It would be my understanding that a test there would include combustion of the coal because we certainly feel that simply cleaning the coal would not be a complete demonstration. I will double check on that, however, and if it is contrary I'll get in touch with you.

Mr. **Walgren**. I will certainly appreciate that because I understood Mr. Vaughan to feel they had a limited role and that they have limited dollars that they are aiming solely at cleaning.

Mr. **Mannella**. The thrust of the cooperative agreement was to get the new coal-cleaning technology that had been developed under DOE contracts into our coal-cleaning facility for evaluation and comparison with the other technologies that we had. Their role is limited and it is identified with the new technology. As I say, it would be my understanding that in a normal course of events we would want to burn that coal.

Mr. **Walgren**. I see. I was struck by the testimony from Mr. Webb and Mr. Baly that the direct recognition of imbalance in the DOE energy R&D programs—as you say, Mr. Webb, at some point to say that this is a balanced program, is a myth—I think you used that word myth. If you were using limited dollars and dividing them among several different alternatives particularly conservation efforts, and other kinds of research that we are doing in coal gasification, fuel cells, other efforts; which would give us more return for the dollar? Is the conservation rate very high in your assessment of where a program aimed at the economic affect of the dollar spent would lie?

Mr. **Webb**. I don't think I can give you just a one sentence answer. The conservation impact in research in conservation is very important and has a dramatic effect. We certainly think that the Federal Government has a role in that and they should devote adequate resources to that to do the long-term research so that there's some viable products coming out of the research laboratories that industry and organizations such as GRI can pick up and take the final step to get it introduced into the commercial marketplace.

However, I think you should really take a long, hard look—if you're going to spend between $1.7 and $2 billion a year, at the DOE basic energy research programs under the Office of Energy Research, and not devote some minimum amount—$35 to $50 million a year—to geosciences of the naturally occurring hydrocarbons in our Earth's crust, which might in fact carry us to the next 100 years with adequate research. I think that's a very important initiative and something this committee has under its jurisdiction and should look at. They're looking at technologies, while they're very important and they establish a scientific base in our universities, it's just as important to rebuild the scientific base in our universities to look at the geosciences in those elements of the country where the natural hydrocarbons occur and understand that phenomenon, which in fact might lead to a lot of different ways to look for oil and gas; a lot of different ways to recover it; a lot of different ways to use our coal resource. I think that should receive a very high priority.

Mr. WALGREN. Thank you, Mr. Chairman.

Mr. BOUCHER. Mr. Traficant.

Mr. TRAFICANT. Thank you, Mr. Chairman. I would like to commend this panel, first of all, on the things brought forward and the insight they presented to me as a new member. In looking at some of these problems, I find it quite alarming that the tremendous amount of investment that the government is making in research and defense and not in our domestic needs is somewhat frightening.

I think your testimony, not only reflects that, but it is impressive and hopefully it will be absorbed by members of this subcommittee and the committee as well.

One question I have here for Mr. Baly. What potential do you see for a compressed natural gas automobile industry in itself?

Mr. BALY. Various studies have been made on that. The most recent one was done by the Georgetown Center for Strategic and International Studies. They identified the potential Federal natural gas vehicle fleet. They identified roughly 290,000 vehicles of the Defense and other Federal agencies alone. The domestic potential is even much greater than that. Mr. Lieber might elaborate on that.

Mr. LIEBER. Current technology makes them most appropriate for fleet use and the current transportation statistics for 1982 showed approximately 8 percent of our highway fleet were in fleets of four or more vehicles.

Basically, we could accommodate that fleet if you calculate the approximate utilization of such a fleet with the current gas bubble of three TCF that's available. That would be the immediate term impact that we could make. Clearly improvements in technology and in general acceptance could expand that impact.

Mr. TRAFICANT. The question I have for Mr. Webb and perhaps for Mr. Mannella is, what would be the greatest thrust we can make collectively through research and development, to ultimately bring down the cost that the average consumer pays for utilities and for energy in this country and further reduce dependence on outside sources of energy that come into this country. Mr. Webb?

Mr. **Webb**. If I could, I would just respond to the gas aspects of it and let Mr. Mannella respond to the electric side. In the gas side, I think there's really three things that need to be done. One, we need to get a consistent viable program that would allow us to use our energy more efficiently. Fuel cells, heat pumps, those sorts of technologies that can truly make a big impact on the cost to the individual homeowners and the commercial establishments in the way they use gas energy.

Second, we need to continue in DOE a long-term research program, and I agree, it ought to be long term research, but it ought to be at a consistent level and a viable level in these advancing technologies to find oil and gas—unconventional natural gas, I would call it. Those type of technologies——

Third, we ought to really establish a viable geosciences research program in our basic energy sciences program to look at the long term aspects of where hydrocarbons may lay, how they were formed, and look at how we might recover them in areas that heretofore we've never even looked at because of the lack of the basic understanding of the knowledge.

Mr. **Traficant**. Thank you. Mr. Mannella.

Mr. **Mannella**. Mr. Traficant, as the years go by toward the end of the century, the existing electric generating plants will continue to age; decisions will be made about replacing them; and, coal will almost certainly be the fuel of choice. One of the uncertainties that hangs over the head of the people that make those decisions, is what the environmental requirements will be; whether there will be any legislation related to acid rain, for example. I think that what we have to do is to make sure that there are suitable technological options for the utilities to burn coal in an acceptable and economically attractive way. If we can use the coal we have in the United States, we will be better off as a nation as far as our overall economy is concerned and we have to remove that uncertainty.

Mr. **Baly**. Congressman, could I respond to that question? You're concerned with coal; most of the panel is concerned with using coal. AGA is only requesting $3 million for select use technology either using gas in reburning technology in a post combustion pollution control method to reduce NO_x and SO_x emissions to assist burning of coal-water mixtures, or gas use to assist oil to coal conversions. Instead of having to put a $100 million scrubber on a coal facility, use gas with coal, backing out imported oil. We think you can make a significant contribution just by looking at that method and trying to advance that technology.

Mr. **Traficant**. Have you advanced that forward in a written form to the committee?

Mr. **Baly**. Yes sir, we have. We have provided, we and GRI both; have provided different projects that we think should be pursued.

Mr. **Traficant**. Perhaps you can make those available to me. One last questions, Mr. Chairman.

On this coal gasification from Mr. Vaughan, the cost outweighed the benefits in his view. This was sort of an explanation of the once commitment of funds toward that type of research and development and now a waning of that. I notice, Mr. Webb, that you make comment of it in your statement. It is sort of like we've started something but haven't totally finished it. What's your response relevant to this coal gasification and how it could play a part in our future?

Mr. **Webb**. Briefly, I think that coal gasification, if you look at the year 2000 and past, probably has a legitimate role. In the near term, I think that will primarily be used perhaps in conjunction with combined-cycle-powered plants to generate electricity which EPRI has one underway. What we were really saying was keep a basic long-term research program. Let's build a test facility. We'll jointly bring our members in and fund a test facility where we can test processes at a sufficient size and scale that you can make realistic economic projections. We think that's a missing key ingredient in the coal gasification program.

Mr. **Baly**. Congressman, if there are difficulties in certain areas, it makes sense to gasify it at one-ninth the pollutant level, at one-sixth the water, one-third the cost, and move it through the million mile pipeline system we have in this country. I think there is a strong potential for that.

Mr. **Traficant**. Thank you.

Mr. **Boucher**. Mr. Fawell.

Mr. **Fawell**. I shall yield to my colleague from Texas who has a schedule problem that I don't have.

Mr. **Boucher**. The Chair recognizes Mr. Barton.

Mr. **Barton**. Thank you, Mr. Chairman. I would like to point out before I ask my questions that my district in Texas is the ninth largest producer of oil and natural gas in the country, if it were a State, and the largest producer of electricity generated by lignite power. I also have a nuclear powerplant that will be going on line just outside my district that's quite sizable. So, I have a personal concern about the energy resources.

I just have a few brief questions to Mr. Baly. I have followed your testimony with great interest and you and I have worked together in the past on several things. I guess my question is, as I look at the budget constraints that we're under this year, I'm not so sure that the Federal Government should be involved in some of the areas that you suggest. I think that the private sector—the private oil and gas companies—might, could do the job better. Specifically, in talking about fracturization for unconventional gas resources, I know that a lot of private oil and gas companies are doing that research also. How would you respond to that?

Mr. **Baly**. I believe that there is a lot of new technology either in the deep drilling or in the tight sand area that many countries like Russia or Sweden do either with gas hydrates or things that are not even presently included in our gas resource base. With a heavy DOE emphasis, for every dollar of gas there is roughly a $16 funding of electricity, it is our feeling that there are energy resources which, with the Government's assistance, we could certainly add to our present resource base.

Mr. **Barton**. I would like to ask a question to Mr. Webb. I guess I should preface this by saying that I understand that GRI and EPRI are really private sector organizations that work with the Government so I'm kind of talking to the choir here, but I noticed in looking through your budget recommendations, in almost every case you requested more funding this year than we actually authorized. When we're looking a $180 to $200 billion deficit, how can we go in in every case and request more funds than we're spending this year, when this year we are $180 billion in the hole?

Mr. **Webb**. I think if you will look at the—part of the $56 million we're recommending is a $35 million redirection in a $1.7 billion program in the Office of Energy Research. That's not new funds or additional funds over last year. Within $1.8 billion, you ought to find $35 million to look at the Earth's crust and the geosciences research associated with that. When you back that out, I think you will find the total recommendation is probably less than what was actually appropriated last year by Congress. Congress appropriated an average of about $125 million and what we're really saying is a three-phased approach.

We are putting up approximately $165 million in 1986 in near-term research. We think that the Federal Government ought to match that on a dollar for dollar basis. We are putting $10 million a year into the near term blanket sands research, many of which are in Texas. DOE has got a small program going in more long term areas. We think they ought to put in $10 million in the long term and we put in $10 million in the near term. That's really the approach that we've taken here. I think the redirection is what's confusing because we are not actually asking for additional funds over what's been appropriated in the past.

Mr. **Barton**. That's all my questions. I would just like to make a general comment. I agree with this panel and some of our other panels that perhaps we need to redirect our funding more toward things that help us near term and help the private sector and away from the defense areas. I hope that we'll look at the requests for dollars in the context of the overall budget problem. I foresee the budget deficit as the No. 1 issue before this Congress and I think we are all going to have to make some choices—to make some priority decisions—about how to spend money so that we can get that under control. I thank the gentleman from Illinois for yielding.

Mr. **Boucher**. Thank you, Mr. Barton. Mr. Fawell.

Mr. **Fawell**. I am new to this committee and new to the whole field so some of my questions betray my ignorance. When we talk about the shift that Mr. Baly and Mr. Webb have done about R&D to the so-called defense-related research, can you tell me what are we talking about in defense related research and especially perhaps in new defense-related research?

Mr. **Webb**. The defense-related research—a lot of the defense budget is weapons production, producing actual weapons at our national laboratories to use as part of our weapons system. There's additionally about $2 billion or so of what we call weapons-related R&D that was categorized as part of the R&D budget. It really has nothing to do with energy R&D. The point I was trying to make is that even if the weapons research is needed, there has been a shift from about 60 percent of what used to be the Department of Energy's budget for energy R&D, to less than 20 percent. That is a fact. We think that ought to be looked at in policy consideration, because if you continue that trend, one of these days we're going to run out of a basic generic base to build upon by industry, and we're going to be back importing levels of oil that are going to repeat the cycles we saw in the early 1970's. I don't think that's good national policy. That's all I was really trying to point out in that part of my testimony.

Mr. BALY. We are not defense experts. We just look at the total numbers and how they're related. I think there is a feeling in the Congress not to go ahead and put all of that research in the Department of Defense—to keep it separated. We are very concerned about the move to continue to diminish not only the research budget, but the fossil budget; particularly in gas, even more so.

Mr. FAWELL. I certainly would agree with that. What affect does this shift that we are referring to, which affects energy R&D in general, have in regard to the environmental problems that are affected? I understand you're all very interested in basic research and technology as it affects gas and coal but what about the problems that we have so far as the environment is concerned? Does the shift away from basic energy R&D have a detriment in that area too?

Mr. WEBB. I would like to defer to Mr. Mannella since they really have the research program looking at the acid rain problems.

Mr. MANNELLA. I think the answer, if I divine your question correctly, is yes it does. The shift is really a reduction in the amount of money that is available to do those things which the people, both in the private sector and the Federal Government feel should be done. For example, EPRI has probably done more work on the acid rain problem than anybody outside of the Federal Government. We are not convinced that there is a linear relationship between a reduction of sulfur oxide and a corresponding reduction in acidification in the Northeast or in Canada. We have spent money and designed an experiment to actually seed the effluants of plants in the Ohio Valley and to track those pollutants on their course, to monitor on the ground and in the air, and to pin down once and for all whether or not this relationship—this program has not gotten off the ground although EPRI has proposed a joint program which we would pay about 25 percent of the cost and I think one of the reasons is that there are some scientific reservations on the part of some of the people. I think one of the other reasons why it has not been embraced is because of the tightness of the budget and the lack of availability of dollars for energy R&D.

Mr. FAWELL. I have no further questions.

Mr. BOUCHER. Mr. Traficant.

Mr. TRAFICANT. I think maybe this subcommittee should recommend to the total committee that this priority on research and development money should be given some consideration and perhaps it might be called to look further into that aspect. I find myself to be very much concurrent with the testimony here and the ideologies presented from this particular panel. I feel that our efforts in R&D should be a little bit more progressive and along the lines of what they have discussed. Perhaps in the form of a recommendation to the Chair at this time, the overall committee should take a look at that priority and the priority that's been budgeted so far. I want to thank this panel for enlightening me as they have.

Mr. BOUCHER. Thank you, Mr. Traficant. The Chair wishes to express its appreciation to the panel as well.

We will not proceed to our second panel and I will ask the following individuals to come forward; Mr. Joseph McElwain, chairman of the MHD Development Corp.; Mr. Robert W. Fri, adviser to the board, Fuel Cell Users Group; Dr. Peter R. Solomon, president of Advanced Fuel Research, Inc.; and Mr. S.R. Hart, Jr., vice president, Southern Co. Services, Inc.

We are glad to have this panel with us today and we will begin the testimony with Mr. Joseph A. McElwain. Mr. McElwain, if you will.

STATEMENT OF JOSEPH A. McELWAIN, CHAIRMAN, MHD DEVELOPMENT CORP., BUTTE, MT

Mr. McELWAIN. Mr. Chairman, my name is Joseph A. McElwain, and I am here representing the MHD Development Corp., however I am a former chairman and chief executive officer of the Montana Power Co. which is involved in electric generation, distribution, and transmission in natural gas production, transmission, and distribution and in coal production to the extent of approximately 11 million tons a year.

I would like to ask the committee if they would accept the written testimony of Dr. Susan Wu, who is administrator of the University of Tennessee Space Institute and have it put in the record.

Mr. BOUCHER. Without objection that testimony will be made a part of the record.

Mr. McELWAIN. And likewise, the testimony of Mr. David Brown, president of the MHD Industrial Forum.

Mr. BOUCHER. Without objection that statement will be received as well.

Mr. McELWAIN. And if my testimony may be put in the record, I will merely summarize a few of the points I would like to make.

Mr. BOUCHER. Without objection, your testimony will be made a part of the record.

Mr. McELWAIN. I think the case has been pretty well made here today that coal is one of the greatest energy resources that we have available to us in the United States. It is beyond a doubt the most plentiful energy source that we have representing 35 percent of the coal reserves of the world. I think it's pretty well the case made that we should be utilizing that coal toward a research and development program that allows that utilization in its most efficient manner and environmentally acceptable. I think the utilization of our great coal resources would go a long way toward helping solve one of the great problems that I view we have at the present time in addition to our deficit spending problem, but that is the problem of the fact that we are sending about $130 billion a year overseas, a substantial portion of that to buy foreign supplies of energy.

I think we must proceed with a program of research and development that internalizes our coal resources. I submit to you that the MHD process has one of the highest payouts if it is pushed forward, of any of those special research and development projects we have. It goes a long way to solving all the environmental problems associated with acid rain. It has the potential of upgrading the utilization of coal from somewhere between 30 to 35 percent efficiency at the present time to possibly 45 to 50 percent efficiency. We should also proceed with a program which was agreed to with the Department of Energy last year at these hearings, and which all of a sudden has been scrubbed.

Last year, Mr. Vaughan presented to this committee a 5 year multiyear program for proof of concept and suggested also that the private industry should proceed with possible retrofitting of a facility located in Montana on Montana Power Co.'s system. The funding of some $29 to $30 million was put up last year with some language that said that this area needs a consistent program of multiyear funding so that we can reach the proof of concept in 5 to 6 years. That level of funding was suggested somewhere around $45 million a year. I think that would be adequate to get the job done in the timeframe I'm talking about.

Commensurate with that and in tandem with it, it was suggested we should be looking at the engineering and go forward with the engineering of retrofitting a coal-fired—excuse me—a gas-fired plant on Montana Power Co.'s system for an MHD topping unit. That would go forward at the same time the proof of concept. We had meetings with the Department of Energy groups that have been interested in this at least—there were five meetings last year—one as recent as December 6, concerning moving this program forward on a multiyear concept. All of a sudden on December 14, the program was abruptly cut off. I suspect that Mr. Vaughan has a feeling that there is a great potential in MHD, as I believe Mr. Hodell did. I think what I perceive happening is perhaps we've got a situation where the OMB is running our domestic energy program and I submit that there are a good many reasons for us to continue to program this important and, I believe will prove, effective means of using coal in a clean manner. That requires the continued multiyear funding of the proof of concept that was agreed to and worked out last year. It also involves the moving forward of the retrofit program that was discussed with DOE. In doing that, MHD Development Corp. was created, early this year, with its charter members being AVCO, Babcock & Wilcox, General Dynamics, Gilbert/Commonwealth, Montana Energy Research and Development Institute, the Montana Power Co., MSE, Inc., TRW, Inc., and Westinghouse. They have submitted a proposal to DOE under the clean coal program which would anticipate a joint funding of 50 percent by this group and 50 percent by the $750 million proposed program that you have authorized.

I submit that I would be hopeful that this committee would continue to recognize the great potential of magnetohydrodynamics to the longtime future of this country and the utilization of its great coal resources, and that it continue to approve the two-pronged approach to this whereby the retrofit program would go forward under the proposal that we have currently before the Department of Energy, and to continue the funding at an adequate level to get to the proof of concept. No show stoppers have come up at this point. We've got $500 million into this effort, and it is just foolhardy not to continue this program in a multiyear program level that will get us where we want to be in 5 or 6 years. I appreciate the opportunity to again appear before you, and I know that you seriously are approaching what I believe one of our future problems is, not only internalizing our energy for use domestically, but also as a defense measure. Thank you.

[The prepared statements of Mr. McElwain, Ms. Wu, and Mr. Brown follow:]

Testimony of Joseph A. McElwain
Chairman of the Board, MHD Development Corporation
before the
Subcommittee on Energy Development and Applications
of the House Committee on Science and Technology
March 14, 1985

My name is Joseph A. McElwain. I am Chairman of the Board of the MHD (Magnetohydrodynamics) Development Corporation. In January, I retired as Chairman and Chief Executive Officer of the Montana Power Company. One of the primary purposes of the MHD Development Corporation is to initiate, promote and coordinate efforts toward effecting commercialization of the technology of Magnetohydrodynamics. The charter companies committed to this corporation are Avco Everett Research Laboratory, Inc., Babcock and Wilcox Inc., General Dynamics Corp., Gilbert/Commonwealth, Montana Energy Research and Development Institute, The Montana Power Company, MSE Inc., TRW Inc., and Westinghouse Electric Company. These companies and I have confidence in MHD.

The first action of the MHD Development Corporation was to propose an MHD retrofit demonstration project that provides for a fully integrated MHD development plant. The Montana Power Company will make its Frank Bird Power Plant available to the corporation as the retrofit host. The companies cited above participated in the proposal which offers to cost share 50 percent of the project on a 50/50 basis with the Government. It was submitted to the Deparment of Energy in response to the Program Announcement: Information Regarding Emerging Clean Coal Technologies, Federal Register, Volume 9, No. 229, 27 November 1984. The proposal entitled "Design, Construction and Operation of a Demonstration Coal-Fired Magnetohydrodynamic Steam Power Plant" also contains letters from the Electric Power Research Institute, Edison Electric Institute, MHD Task Force, and five representative utilities supporting the continued development of the MHD technology and this proposed demonstration project.

Formation of the MHD Development Corporation and the offer to cost share the project are tangible proof of industry interest, commitment and belief in the potential of the Magnetohydrodynamic technology. These charter companies are proposing a large stake in the project and are committed to its successful completion.

This corporation and its proposed project would not have come to fruition if the MHD technology development had not been able to meet its milestones or if the DOE had not developed its multiyear, proof-of-concept program directed toward an MHD retrofit. You can understand our discouragement, disappointment and frustration when the DOE proposed terminating the MHD effort in FY 1986.

DOE's multiyear program directed towards an MHD retrofit demonstration plant, which DOE presented to Congress in June, 1984, is a good program and an essential program if MHD is to come to fruition. The ramifications of dropping this program will affect many areas beyond MHD power generation. The nation's energy independence program, its credibility in high technology development and the Government's credibility as a partner in any cost-sharing venture are all at stake. Industry is serious about MHD, but it must have a partner, a reliable partner: the Government.

The DOE's June plan recognized that MHD is not a mature technology. MHD has high cost and a long lead-time to ultimate development. DOE's offer to make the CDIF and CFFF available to industry for further development is mute and unrealistic. Industry does not have the resources to assume responsibility for the proof-of-concept program. If the MHD development is to progress, the Federal Government must continue to underwrite the proof-of-concept with about the same level of private participation that already exists.

Substantial industrial investment will not begin until the retrofit stage. The near term financial conditions of the utilities and supporting industries does not permit substantial cost participation prior to the demonstration facility. As with all new and old technologies, substantial risk will still be present in the scale-ups required and in the first integration of all the MHD components into a working system in the demonstration plant. Any return on investment is a long-term situation, even after the demonstration project for marketing itself is lengthy and expensive. For MHD to be marketable, the durability and reliability tests must be successfully completed. Still, the large potential benefits indicate the risks are worthwhile.

The DOE plan says that "the MHD program has reached a critical decision point; the technology is ready for integrated proof-of-concept system/subsystem tests. It is time to focus the program on the least-cost, shortest development path to establish the technology base for MHD power systems." Upon successful completion of this program, the DOE plan calls for a "preliminary design (Title I) of the retrofit in late 1987 and the detailed design (Title II) in late FY 1987 or 1988." The MHD Development Corporation strongly supports this position and has designed its proposed MHD retrofit project to correspond to the DOE plan and to serve as the focus for the DOE's proof-of-concept program.

The proposed MHD retrofit at the Bird Plant would bring all the components and subsystems in a fully integrated facility for the first time and at a utility site. The size would be sufficient to address the technical phenomena that occurs with scale up, as well as large enough to address the risks involved in the additional scale up required for a commercial plant.* It also will provide economic data and "hands on" utility operator experience. Transition to commercial demonstration would commence about 5.5 years after beginning of the preliminary design.

These project milestone dates can only be met if DOE's core program to test the components and prototypic hardware is maintained and taken to completion. The work initiated in previous years and being carried on at both the CDIF and CFFF in regards to coal combustion, channels, HRSR and downstream development, needs to be completed at the same time as the initial design stages of the demonstration project. Both aspects of this program, the DOE core proof-of-concept program and the demonstration project are timely and necessary to take the MHD technology to a useful completion.

As requested by the referenced PON, substantial (50 percent) sector cost participation is proposed. The industrial participation is backed by companies having the capability, experience, and resources to support this commitment. They have documented with letters of intent their willingness to participate with the Federal Government in this worthwhile project. Yet, participation with the Government as a partner does have its problems. These problems should be recognized both from the industrial and Government viewpoints. For example:

1. Current market conditions.
2. Market penetration costs and risks.
3. Patent positions.
4. Tenuous Government funding by Congress and/or the Administration.
5. Need for assurances of continuity.

It is encumbent on the Federal Government to prove itself as a reliable partner. A multiyear program directed towards the retrofit is essential. A return to the five year plan proposed by the DOE in their 1985 budget presentations is needed. A five year program alone, without adequate funding, would not achieve the goals required. Adequate funding would be approximately $40 million a year accompanied by a firm and reliable Government policy to pursue the proof-of-concept program to fruition. The start-stop policies of the past have minimized the effectiveness of the monies spent. The history of MHD does not give anyone confidence in the Federal Government as a reliable partner in developing energy systems.

Industry has contributed over $40 million to the development of MHD and can be expected to continue to contribute during the proof-of-concept program. The amount that will be contributed will depend upon Industry's perception of how serious the Government, and particularly the Administration, is regarding the continuation of the MHD program.

Since 1973 when the United States received the signal of our vulnerability to dependence upon foreign sources of energy, the need for internalizing our energy capability through the greater utilization of our vast coal resources has been recognized. As you are well aware, we have substantial political and socio-economic problems to overcome before nuclear power becomes a continuing source of supply for our increased electrical energy needs. This leaves our great coal reserve as the one reliable source of internally generated energy. The United States possesses over 35 percent of the known coal reserves of the world, some 450 billion tons. The states of Montana, Wyoming and North Dakota possess approximately 45 percent of the U.S. coal reserve.

It is clear that coal must assume an increasing part of our national fuel mix. We all know how the coal window has enlarged versus the previously perceived nuclear option. But we have not been moving with dispatch in this critical area. In 1974, only 44 percent of the electricity produced by utilities came from coal. In 1980, that figure had grown by only 6 percentage points -- to only 50 percent -- while the consumption of electricity had leaped 19 percent.

Looking just a few years into the future, the best forecasts indicate that the demand for electricity will escalate 114 percent by the turn of the century because electricity is that blessedly versatile form of energy that can serve many needs. Coal could and should be used to generate more than 2/3 of our total electricity, assuming attractive economics and superior technology.

Yet, without MHD or some unforeseen exotic technology, coal cannot be expected to assume its destiny in our energy mix. Only with the massive gains in efficiency, economics and environmental control offered by MHD can coal play its assigned part in the shift from primary reliance on shrinking oil suppliers to our relatively abundant coal reserve. Prolonging the life of our coal supply through the efficiencies of MHD suggests that we should follow a course that will bring about expeditious application of this promising technology.

From the perspective of coal utilization, MHD presents the only direct coal conversion technology on the scene today that increases efficiency as well as meets environmental standards and goals. MHD can utilize all coals, both low and high sulfur.

MHD is a relatively simple conversion process which moves a hot conductive gas through a strong magnetic field which then causes current to flow in the gas. MHD has the highest potential efficiency of all the new coal-burning technologies; its combustion process inherently controls SO_x and NO_x. The impacts of burning coal 50 percent more efficiently has tremendous benefits in addition to fuel savings by reducing related environmental impacts through less mining, less transportation and less effluents.

From the perspective of the national need for electricity, a shift to electricity has evolved over many decades, as unique applications have been developed capitalizing on electricity's special end-use flexibility. Over the past 20 years, the total electricity made available for use in the United States has increased by more than 150 percent. The use of electric power continues to parallel the U.S. Gross National Product (GNP). Over the past 10 years non-electric energy use has declined by 16 percent while electric power consumption has grown by a total of 25 percent. During this time span, the economy expanded by 25 percent. An increased use of electrical power has occurred in every sector of the economy -- residential, commercial and industrial. Again from 1973 to 1983, residential and commercial demand increased by 26 percent and 35 percent, respectively. Industrial use has rebounded from the 1982 decline, increasing 4.2 percent in 1983 and by a total of 13 percent since 1973.

From the perspective of the state-of-the-art for MHD, its track record in meeting its milestones is well known. Some of the advances warrant repeating from my testimony before this committee last year.

"The dollars spent have brought significant advances in recent years in areas which at one time were considered show stoppers.

1) Channel life has gone from seconds to minutes to 1300 hours testing and an extrapolated life of 8000 hours.

2) A 4800° coal combustor has been successfully developed and tested by TRW at the 20 MW_t level and 80 percent slag rejection with testing of a 50 MW_t combustor under way.

3) High temperature air heaters have not been successful. The near term alternative is the use of oxygen enriched air at a 3 to 4 percent efficiency loss, while development continues.

4) Steam bottoming data is encouraging - Argonne National Labs and CFFF have successfully used soot blowers to strip MHD-type ash from tubes and run successful coal-fired tests.

5) A super conducting magnet of 6.2 Tesla has been built and tested at Argonne National Labs.

6) A successful DC-AC inverter was developed by the Electric Power Research Institute and installed/operated at the CDIF.

7) Environmental Intrusion - CFFF tests on SO_x and NO_x are well below EPA limits.

8) Spinoffs have occurred - atmospheric slag rejecting coal combustors - low NO_x combustors - high temperature heat exchangers - hot gas (plasma) research, etc."

In summary, I urge adequate financial support of MHD as a technology whose long-term promise transcends parochial interests and the immediate Federal commitment to a broad range of budgetary stringencies. MHD offers our nation, its utility customers and its utilities exceptional opportunities to replace dwindling oil reserves with coal in our total energy mix; to conserve our lone abundant energy resource by making the most efficient possible use of coal; to burn coal in the most environmentally acceptable, efficient manner;

to facilitate the ability of utilities to meet national energy goals; and to offer the user of electricity hope of genuine progress being made in combating the escalation of the price of that energy form. I believe continued support for MHD is imperative in the context of national interest. In conclusion, let me repeat: MHD has been funded for the past several years at $30 million, the absolute minimum needed to make meaningful progress. To achieve adequate progress in the proof-of-concept phase, $40 million is required annually. Thank you for your attention and consideration.

Summary

Testimony of Joseph A. McElwain

Chairman of the Board, MHD Development Corporation

before the

Subcommittee on Energy Development and Applications

of the U.S. House of Representatives

Committee on Science and Technology

March 6, 1985

My name is Joseph A. McElwain. I am Chairman of the Board of the MHD (Magnetohydrodynamics) Development Corporation. One of its primary purposes is to initiate, promote and coordinate efforts toward effecting commercialization of the technology of Magnetohydrodynamics. The charter companies committed to this corporation are AVCO; Babcock and Wilcox, Inc.; General Dynamics Corp.; Gilbert/Commonwealth; Montana Energy Research and Development Institute; The Montana Power Company; MSE, Inc.; TRW, Inc.; and Westinghouse Electric Company. I and these companies have confidence in MHD.

The first action of MHD Development Corporation was to propose an MHD demonstration project that provides for a fully integrated MHD development plant as part of the Emerging Clean Coal Technologies program announcement. This proposal contains letters from the Electric Power Research Institute, Edison Electric Institute MHD Task Force and five representative utilities supporting the continued development of the MHD technology and this proposed demonstration project.

Industry is serious about MHD but it needs a reliable partner in the government. In fact, MHD cannot proceed without the Federal government's support.

The progress made in working with the Department of Energy in many meetings over the past year was most satisfying. The DOE multi-year proof-of-concept program directed to an MHD retrofit demonstration plant, was presented to Congress in June, 1984, and was a culmination of these efforts. It is a good program, provides for cost participation by industry and should be followed.

It was disappointing and frustrating when DOE again changed its mind and recommended cancellation of MHD. This, after the extensive collaboration with industry, at the request of the Department of Energy, on the merits and economics of developing MHD. The bottom line is that industry cannot develop MHD by itself. It is too long-range and too risky. DOE recognized the need for government cost participation in the plan it presented to Congress last June.

DOE's offer of making the CDIF and CFFF facilities available to industry for further MHD development is moot. Industry does not have the financial resources to develop MHD, even given the two named facilities. Therefore, the government will have expenses in mothballing these facilities, not to mention the loss of current investment. This loss would be on a technology which has been very successful to-date and has great potential for the nation and the utilities.

The potential economic and environmental benefits of MHD of burning any grade of coal directly 50% more efficiently warrants continued development of the technology. The savings from just two mature MHD plants would pay for all the research, development and demonstration costs for MHD.

The ability of this technology to meet its milestones is well known. The need for energy independence is well known. Our vast coal resources are well known. Then why isn't coal research being pursued with vigor and why isn't MHD with its potential of being the most efficient, economic and environmentally acceptable direct coal-burning technology being pursued.

The program that the Department of Energy developed with industry would continue proof-of-concept/subsystems development at the present test facilities. These development efforts would be directed toward an MHD retrofit system at a utility site. This program would develop the MHD technology in the shortest possible time, at the least cost to the government and include industrial participation. The government must carry the bulk of the funding and be a reliable partner in both the proof-of-concept and MHD retrofit demonstration plant for MHD development to continue.

The United States currently has the technical lead in coal-burning MHD technology. Many other countries, including China, Japan, Italy and the Soviet Union, have MHD development programs, for they recognize the potential also. If we stop MHD development now, we will probably buy it from overseas sometime in the future.

The potential energy independence to the nation and savings to the utility customer are very large. The saving from just two full-size mature MHD plants would pay for all of the research, development and demonstration costs.

The long-term promise of MHD as a technology transcends parochial interests and the immediate federal commitment to a broad range of budgetary stringencies. MHD offers our nation, its utility customers and its utilities exceptional opportunities to replace dwindling oil reserves with coal in our total energy mix; to conserve our lone abundant energy resource by making the most efficient possible use of coal; to burn coal in the most environmentally acceptable, efficient manner; to open new markets for coal types that are now uneconomic for utility use; to facilitate the ability of utilities to meet national energy goals, and to offer the user of electricity hope of genuine progress being made in combating the escalation of the price of that energy form. I believe continued support for MHD is an imperative in the context of the national interest.

Thank you for your attention and consideration.

JOSEPH A. McELWAIN

Born in Deer Lodge, Montana - November 13, 1919
Son of Lee Chaffee and Johanna (Petersen) McElwain

Education: Powell County School System, Deer Lodge, Montana
BA Degree - University of Montana, 1943
LL.B Degree - University of Montana, 1947
JD Degree - University of Montana, 1970

Veteran World War II and Korean War

Married Mary Cleaver Witt - March 8, 1945
Children - Lee William and Lori Louise (twins)

Private practice of law - Deer Lodge, Montana, 1947-1964
City Attorney Deer Lodge, Montana - 1950-1957; 1960-1963

Montana Power Company:
Washington Legislative Counsel - 1954-1963
Counsel for Montana Power Company - 1963-1965
Assistant to the President - November 1, 1965
Vice President - June 21, 1967
Executive Vice President - November 24, 1970
President and Chief Executive Officer - March 1, 1975
Chairman, President and Chief Executive - May 1, 1978
Chairman and Chief Executive Officer - January 1, 1979 - May 3, 1983
Chairman of the Board - May 3, 1983 ---

Directorships:
Montana Power Company and subsidiaries - November, 1970 ---
Development Corporation of Montana - January, 1971 ---
Pacific Northwest Power Company - February, 1973 ---
First Bank System - April, 1976 ---
Business-Industry Political Action Committee - November, 1980 ---
Montana International Trade Commission - November, 1980 ---
Edison Electric Institute - June, 1981 ---
Pacific Steel, Hides, Furs, Recycling - July, 1983 ---
National Association of Manufacturers, Montana Director - August, 1983
Montana Energy and MHD Research & Development Institute (MERDI) - January, 1984 ---

Past Directorships and other:
National Association of Electric Companies - 1973-1976
First Metals Bank & Trust Company - 1974-1976
Rocky Mountain College, Billings - 1974-1978
Policy Committee on Research, Edison Electric Institute - 1975-1979
Butte Cultural Arts Board - 1976-1979
Board of Trustees, Western Regional Council - 1977-1980
Advisory Committee, Edison Electric Institute - 1975-1981
United States Chamber of Commerce's Natural Resources Committee - 1971-1975
National Assn. Manufacturers' Public Relations Committee - 1971-1974
Business Administration Advisory Council, U. of Montana - 1977-1982

Trustee or Member:

Montana Public Land Law Review Advisory Committee
University of Montana Foundation, Missoula - 1958-1964; 1972 ---
(President of the Foundation - January, 1983 ---)
United States National Committee, World Energy Conference - 1971 ---
American Power Study Team - Germany - 1972 for U.S. Dept. of Interior
Lewis and Clark National Historic Trail Advisory Council for the U.S. Dept. of Interior - December, 1980 ---
C.M. Russell Museum Development Council - March, 1982 ---

Civic and other memberships:

Council Executive Board of Boy Scouts of America - April, 1971 ---
Masonic Lodge, Shrine, Elks, Knights of Pythias, Kiwanis Club
Montana State Bar Association, American Bar Association
Co-Chairman, Religious Facilities Center Fund Drive - 1979-1982
Butte Junior Achievement Board member - January, 1980-1982
Honorary Legion of Honor Degree, International Supreme Council, DeMolay
Volunteer State Chairman-Montana, U.S. Savings Bonds - 1980 ---

Served as a member of the Montana House of Representatives 1949-1955;

Majority Floor Leader of the House of Representatives-Montana - 1951
Member Montana State Senate 1962-1964; State Chairman of the Republican Central Committee for Montana - 1952-1954
Montana State Finance Chairman - Reagan-Bush '84

Summary of
Statement of
The MHD Industrial Forum
1725 DeSales Street, N.W.
Washington, D.C. 20036
Dave Brown, President

to

The Subcommittee on Energy Development
and Applications
Committee on Science and Technology
U.S. House of Representatives

March 6, 1985

This statement describes how, at the invitation of the Assistant Secretary for Fossil Energy, the private sector entered into a series of meetings throughout 1985. As a result of these consultations, DOE prepared a plan to redirect its MHD program to "proof-of-concept tests" at the major government facilities.

In response, industry submitted two proposals to the Department of Energy to retrofit an MHD unit to an existing power plant. The proposal submitted by the newly formed MHD Development Corporation offered to cost share 50% of a project to design, construct, and operate a retrofit system using an existing Montana Power plant.

The statement explains that industry does not have the resources to now assume responsibility for the remainder of MHD development, even with the government's offer to make its test facilities available.

If MHD development program is terminated, the investment made by the government and the private sector will be wasted and the government will be left with two large multimillion dollar facilities to mothball and maintain.

Furthermore, if the government terminates MHD after industry's response to DOE's offer to collaborate, it is unlikely that industry will welcome any further invitation to participate in cost sharing programs.

MHD is the only DOE technology under development which converts coal into energy without intermediate steps and reduces SO_x and NO_x dramatically below EPA standards.

The statement recognizes that all high technology development programs involve substantial risk, high investment and often long development and marketing gestation periods and calls for congress to develop a national policy appropriate for industry/government collaboration on non-defense high technology development.

Without this, the statement suggests the U.S. will be unable to maintain its leading position in high technologies other than those supported by DOD and NASA. Such a policy is necessary if the U.S. is to compete with foreign government/industry collaboration.

TESTIMONY
ON THE MAGNETOHYDRODYNAMIC (MHD) PROGRAM OF THE DEPARTMENT OF ENERGY (DOE)

PREPARED FOR THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY

March 6, 1985

BY
Y. C. L. (SUSAN) WU
PROFESSOR AND ADMINISTRATOR
ENERGY CONVERSION RESEARCH AND DEVELOPMENT PROGRAMS
THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE
TULLAHOMA, TENNESSEE 37388

Mr. Chairman and Members of the Subcommittee:

I am Yin-Chu Lin (Susan) Wu, Professor of Aerospace Engineering and Administrator of the Energy Conversion R&D Programs at The University of Tennessee Space Institute (UTSI), Tullahoma, Tennessee. It is indeed a great honor for me to have this opportunity to testify in support of the federal government's role in energy research and development, relating to clean coal technologies in general, and restoring funds on magnetohydrodynamics in particular.

It has been an established historical fact that the use of electric power parallels the U.S. Gross National Product (GNP). Even the 1973 oil embargo disruption did not change the correlation despite the decline of the overall energy use during the last 10 years. The forecast made by the Department of Energy is that during the 1990-2010 time period at least 400 GWe of electrical generating capacity is projected to be placed in service in the U.S., either as new or replacement power plants. A significant portion, as high as 300 GWe, can be expected to be coal-fired plants. Among the direct coal conversion technologies known today, MHD offers the highest efficiency potential while meeting all the environmental requirements. Even for an early commercial plant, a 20% improvement is projected (from 33% efficiency to a 41% early commercial MHD plant), while a 50% increase in efficiency is possible for a mature plant. In 1983 625 million tons of coal were used to generate electricity. A 20% improvement in efficiency would have saved 125 million tons of coal. Several billion dollars per year would be saved, thereby justifying the expenditure of a few million dollars per year during the development phase.

The MHD program is in the proof-of-concept testing stage today as outlined by DOE. The integrated long duration testing at the Component Development Integration Facility (Montana) and the Coal Fired Flow Facility (Tennessee), and prototypic components development must be carried out to provide an engineering data base for successful demonstration of MHD technology. Given adequate funding, the proof-of-concept phase should be completed in the next five years. The next logical step is a demonstration plant. The least expensive and shortest time to bring MHD to the marketplace is through retrofitting an existing plant. With the two programs moving in parallel, the MHD retrofit can start conceptual design in 1986 with construction complete in 1991 and developmental test operation completed by 1995. The proof-of-concept program can expect a 10% private sector cost sharing with the federal government fund at $40 million per year level, while up to 50% cost sharing can be expected for the retrofit plant which costs approximately $412 million.

There have been impressive technical advancements made by all MHD contractors. During FY84 TRW delivered the first stage of the 50 MWt combustor to the CDIF in Montana. Good test results were obtained. AVCO continues the development of the MHD channel, while the STD Corporation has made significant contributions in the three-dimensional calculations of MHD flows which are being confirmed by experiments performed at Stanford University. Superheater and air heaters were installed and checked out at the CFFF. A baghouse was partially installed and an electrostatic precipitator will be installed during this fiscal year.

ANL, B&W, MSU and UTSI are working together on the Heat Recovery/Seed Recovery (HRSR) system. Important data have been obtained on pollution control, heat transfer, boiler tube fouling, corrosion, and seed recovery.

MHD is the "high-tech" of coal technology. As a result, a number of spin-offs have already made important contributions in the energy and environmental fields. For example, the slagging combustors developed by TRW for possible retrofitting of oil fired boilers to coal; full slag carry-over combustors developed by UTSI used for incinerating PCB (already commercialized by a small business); dense phase coal transport, improved by UTSI, has broad applications including heat engines; diagnostics developed by Mississippi State University could be used in other coal combustion systems; NO_x and SO_2 control methods developed for MHD at UTSI can be applied to other coal technologies, just to mention a few. Undoubtedly, there will be other spin-offs from MHD in the future.

There has been significant activities on the international scene, especially in the eastern blocks. The Soviet Union has a number of facilities working on MHD, both for commercial power generation as well as for special applications such as light-weight, high-power mobile systems. In addition, they are building a 500 MWe MHD power plant near Ryazan. The Netherlands, Italy, Japan, China, Israel, Poland, India and Australia all have ambitious MHD programs. Last year several organizations, including UTSI, received a request for quotation from "ROMENRGO", a foreign trade company of Romania, for a 150 MW natural gas fired MHD plant for the Bucharest-Progresu power station. The U.S. is still in the proof-of-concept stage of development and unable to sell an MHD plant today. Unfortunately, MHD power plants will not be sold either domestically or overseas if the MHD program is stopped now.

MHD INDUSTRIAL FORUM

Suite 805, 1725 DeSales Street, N.W., Washington, D.C. 20036 (202) 775-8609

March 18, 1985

The Honorable Don Fuqua, Chairman
The Committee on Science and Technology
United States House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

In response to Mr. Boucher's request to Mr. Joseph McElwain, Chairman of the MHD Development Corporation, during his appearance before your Subcommittee on March 14, 1985, I am pleased to provide the enclosed information on the private sectors contributions to MHD. These figures represent resources -- funds, equipment, goods and services which have been provided to the development effort up to December 31, 1984. The amount allocated for 1985 is shown separately.

This list is incomplete since only those companies and institutions whom we know are involved in MHD have been contacted and some of those were unable to fully respond in time for the report. We are confident that resources at least equivalent to the value of those shown in the report will continue to be made available throughout the DOE proof-of-concept (POC) program. If the preliminary design of the retrofit begins during the POC, which hopefully it will, industry will contribute to that separately as part of the cost sharing contribution as indicated in the proposals recently submitted to DOE.

In addition to these contributions, there are others not included. For example, General Electric, Babcock and Wilcox and others have contributed various goods, services and equipment to the University of Tennessee MHD program, including a Baghouse provided by Environmental Elements, Inc.

However, there is growing concern among many of our member firms that investments made in MHD may have been misplaced. The MHD community was very encouraged last year by the DOE POC plan and responded with proposals to cost share the retrofit phase of the development program. Unfortunately, the Administration's decision to rescind FY 85 funding and terminate the MHD program was done in a precipitous manner and with no forewarning to the industries and institutions with whom DOE had consulted in preparing its POC plan. Both the decision and the way it was handled has raised serious questions about the wisdom of investing valuable resources in government energy R&D programs. No publicly owned company can place its shareholders' investments in a joint venture with a partner whose commitment is always in question.

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The amount of money that will be authorized and appropriated in FY 86 will be viewed as a measure of how serious the government is about developing MHD within a reasonable time. For the past several years the MHD annual budgets have been $30 million; barely enough to make progress. Substantial progress requires $40 million. Less than $30 million means a slow down and substantially less than $30 million will allow only maintenance of facilities and some small capability.

As we described in the Forum's testimony, industry cannot expect to see a return on its investment in MHD until some years after the first truly commercial plant goes into operation. In deliberating the issue of MHD development, the principal issue should not be the benefits that industry will derive from MHD, but rather the environmental, economic and other benefits which MHD can make to the nation.

The Congress and this Committee in particular, has always taken the lead in recognizing the nation's need for developing high technologies, and we are confident it will continue to do so with MHD.

I hope the report will be satisfactory, but if you need additional information, please call upon me.

Very truly yours,

Vincent J Coates, Jr.
pdc
Vincent J. Coates, Jr.
Vice President

VJC/pdc

Encl.

cc: D. Brown
cc: D. O'Neill
cc: G. McCarthy

INDUSTRY AND OTHER NON-FEDERAL GOVERNMENT CONTRIBUTIONS TO MHD DEVELOPMENT

(000)

	Thru 31 Dec.1984	Budgeted in CY1985
Electric Power Research Institute	$10,000	$ 300
Edison Electric Institute	300	25
Southern California Edison	800	150
Montana Power Company	75	28
American Electric Power Company	1,000(1)	
Reynolds Metals	6,000(1)	
General Electric	2,000(1)	
TRW	10,000	750
Avco Corp.	17,000(1),(2)	2,000
MERDI		50
MSE Inc.	-0-	115
MHD Development Corp.		100
Univ. of Tennessee Space Institute	105	30
Mississippi State University	478	100
State of Montana	500	350
State of Tennessee	1,100	
	$34,058	$3,998

(1) These funds were for the most part used during 1960-1970 period to finance the research that established foundation for the later Government component development and testing.

(2) $7 million of this was contributed since 1970.

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MAGNETOHYDRODYNAMICS

Proposed Cost Sharing for Proof-of-Concept Demonstration and Commercialization

MHD Forum Study Panel
Peter G. Marston - Chairman

It is the intent of the private sector, as represented by the MHD Forum, to share with the Government, on a 50/50 basis, the cost of a fully integrated, coal fired, MHD "retrofit" at a utility site. The Forum believes that such an investment is both reasonable and achievable provided that stable Government commitments can be assured and that the Department of Energy's proof-of-concept testing program is pursued through successful completion.

Cost sharing through the reference POC testing program will continue at the approximately 10% level.

The following discusses the salient issues, strategy and schedule.

Background

The present U.S. effort can be thought of as having two major elements; proof-of-concept and demonstration. The present POC phase will demonstrate long-term performance, survivability, etc. of the MHD flow train (at CDIF), downstream components (at CFFF), and seed recovery. This activity will take approximately five years. The demonstration is a proposed 35 MW_e retrofit at Montana Power's Frank Bird Power Plant. This will be a complete integrated MHD system including new HRSR equipment. This activity is also assumed to take approximately five years. There will be some obvious overlap but two five-year periods simplify display of relative Gov't./industry cost shares for POC and demonstration.

It is assumed that value from international collaboration would flow through the U.S. private sector as a result of industry/industry agreements. It is most likely that this value would be associated entirely with the construction of the retrofit plant.

Strategy/Schedule

The target is a power producing 35 MW_e "Bird Plant" retrofit in 10 years.

The proposed "retrofit" cost sharing is 50/50 (Gov't./Industry).

The proposed POC cost sharing is 90/10.

The private sector financing will be provided by "The MHD Development Corp." representing a consortium of private interests. This will facilitate complex joint funding and management.

A detailed study of the technological and investment issues has been initiated. Specific recommendations will be completed during 1985. Detailed negotiations will take place during '86 and '87 and agreements in place shortly thereafter.

Immediate effort will focus on the issues identified in the attached discussion of cost sharing, international collaboration and commercialization of MHD.

COST SHARING, INTERNATIONAL COLLABORATION AND COMMERCIALIZATION OF MAGNETOHYDRODYNAMICS

INTRODUCTION

Within the past few years, these general topics have undergone what many writers describe as "historic change". All three elements are critically interdependent and study is vitally important to the Federal goal of reduced Government expenditure in Energy Research, Development and Demonstration. The salient issues include the following:

---- There is a strong DOE emphasis on private sector cost sharing. For some elements it is a programmatic requirement.

---- International collaboration (with Japan in particular) can create serious disincentives to investment by U.S. industry. Even long-term energy markets (like Fusion) have near-term "spinoff" markets which can cause conflict.

---- Projected energy markets and market segmentation are at best uncertain. Government and industry policies are at best "laissez faire". There is, however, general agreement on the economic and strategic need for advanced technology (in the next 10-20 years) but little agreement on "how to get there".

---- Although present global economic stress creates incentive for sharing the cost of large development and demonstration projects, there are a number of impediments which must be carefully considered. These will differ with different countries. The following relate specifically to Japan;

- In the past, U.S. programs have often served to stimulate proportionally smaller, parallel, duplicative programs in Japan. "Information exchange" with such programs is generally perceived as being "one-way", thus creating disincentive to U.S. private investment. Such "exchange" is important but care must be taken to assure equity.

- The days of significant cash-contribution (from Japan) are probably over. Joint construction ventures are both sensible and feasible but must overcome sizable practical, legal and political obstacles including;
  - -- Japan's perception of the U.S. Government as an unreliable partner.
  - -- National policies and priorities.
  - -- Licensing law and precedent.
  - -- Ability to equitably fund relative to availability of R&D results.

For a variety of reasons, direct coal-fired MHD is a particularly well suited example for study of advanced energy commercialization.

---- it is technologically complex yet ultimately offers the greatest simplicity and cost advantage for commercial power generation; it is also ideally suited for several important industrial processes.

---- its high risk, high payoff and schedule for implementation are in harmony with Federal policy and long range economic and strategic projections.

---- its use and technology base are broadly applicable with many industrial applications, spinoffs and opportunities for collaboration on both systems and individual components.

---- present U.S. and Japanese programs are complementary (not duplicative). The emphasis in the U.S. is Oepn Cycle, Linear and in Japan, Closed Cycle Disk. Potential for complementary interaction exists in several other countries including Cnina, The Netherlands and Italy.

---- the technology status, focus and time are ideally suited to establish a clear set of policies, objectives and a program plan, and to take the lead to initiate a joint planning effort aimed at large scale collaboration.

REPORT

The effort should generate a report intended to be a concise, readable and practical guide to Cost Sharing, International Collaboration and Commercialization of MHD. It should identify and summarize the issues and document pertinent experience. Reference material should include a summary of Federal and State investment incentives for both large and small business, definitions of terms and a brief description of the major econometric models used to forecast long range energy/economy relationships.

The following is a preliminary outline of the proposed report:

1.0 INTRODUCTION

Summary discussion of the global issues and conclusions.

2.0 COST SHARING

This section will document experience, discuss attitudes and make recommendations (within the general range of consensus reached) for cost sharing in each of the following phases:

Proof of Concept
Demonstration
Commercialization

and for each of the following private sectors:

Utilities:	Including the role of Industry Associations and the impact of Federal and State regulation.
Industry:	Including (and identifying the separate interests of) Private Research, Architects and Engineer Constructors, Equipment Manufacturers, and Finance. The special interests and attitudes of the coal industry should be included.

Universities:	Although "not-for-profit" organizations generally have no mechanism for direct cost sharing, considerable cost benefit can accrue from careful coordination with other programs, sharing of national facilities, and the international collaboration prevalent within this sector.
Incentives:	This section should include a comprehensive list of Federal and State Programs, legislation, etc. designed to either provide or stimulate investment in advanced energy technology. A special listing for small business should be included.
Disincentives:	The influence of a few of the more important factors which discourage investment should be discussed including: present market uncertainties and their long-term impact; Government interference with the normal private investment/market process; Government regulation and procurement procedures; Poorly orchestrated international collaboration.

3.0 INTERNATIONAL COLLABORATION

This effort should specifically address collaboration with Japan. A brief comparative comment for other countries should be included.

The discussion should assess the relative merits of several different scenarios, each having different relative involvement of Government, Government Agencies, Industry Associations and individual corporations. The university role should also be addressed. Particular attention should be given to the problems of joint construction ventures undertaken on a primarily industry-to-industry level. It should provide a clear basis for both Gov't. and private sector assessment of the potential risks and benefits of international collaboration.

4.0 COMMERCIALIZATION

This section should include a general discussion of the overall process, its time, cost and factors which influence success. It should identify and define the elements and milestones critical to the technical and economic transition from Government to industry.

A brief description of the principal econometric models used to forecast long-term energy/economy interactions and a review of recommended references which discuss the causes and remedies for the severe economic stress on energy industries should be included. The purpose of this inclusion will simply be to broaden the reader's perspective rather than any attempt to solve the global problem and/or recommend policy.

AVCO

EVERETT RESEARCH LABORATORY, INC.
2385 Revere Beach Parkway
Everett, MA 02149

Interoffice Memorandum

Date: February 19, 1985

To: V. J. Coates, Jr.

From: L. Costello

Subject: Cost Sharing Government Contracts

Copy To:

This memorandum is in reply to your request for examples why contractors do not desire to participate in cost sharing contracts with the Government.

Rather than go into a lengthy philosophical dissertation and repeat what others have long complained about regarding doing business on a cost sharing basis, I will simply review an actual Department of Energy, Program Research and Development Announcement (PRDA).

It is expected that the PRDA will result in multiple cost sharing contract awards of differing values. The PRDA states "a minimum 25 percent contractor cost sharing is desired." Let us assume a potential contractor interprets the 25 percent as required rather than desired and that the contribution will be in terms of unbilled allowable costs rather than contributions in kind. In addition, for purposes of this memorandum, the total estimated value is $10,000,000. The resultant proposal provides for a 75 percent cost recoupment of $7,500,000 and no fee, since none is allowed under the terms and conditions of the particular PRDA.

The contract will include a cost sharing of any overrun. This share may be similar to the basic contract 75/25 percent share. Most likely it will be a share more favorable to the Government. This belief is based on the premise that overruns are due to contractor's problems rather than situations created by the Government. For purposes of discussion, a sharing of 70/30 percent is considered reasonable.

The resultant contract also requires ceilings on the indirect expenses (overhead and general and administrative expense) for a period of five years. For contractors doing substantial business with the Government, sales projections for five years are vague at best. After all, DoE itself may not survive the next five years. The indirect costs are expressed in terms of percentages. These percentages have a contractor expense pool as a numerator and a denominator determined by business projections. These projections include the contractor's opinion of the probability of capturing certain commercial and Government contracts if such became realities. Although the contractor should be responsible for the cost elements included in the indirect expense pools (numerator), some relief should be afforded from such ceilings when the business projections (denominator) do not materialize because of Government changes to its planned and prospective programs included in the aforementioned projections.

This memorandum, up to this point, has addressed "voluntary" cost sharing aspects of the program. After all, the contractor has agreed to the basic cost share, the overrun share, and the indirect ceilings.

Now "involuntary" aspects must be addressed. If the Government fails to provide sufficient funding on a timely basis, the contract may be terminated. If the Government determines that for any other reason the program should not be continued, it may exercise the termination clause. Such terminations are unilateral which means the contractor has no official voice in such a decision. Consequently, under conditions of termination, the contractor's share of the actual expenses would not be recoverable.

Other cost impact concerns are the terms of the changes clause which unilaterally directs Government changes to the work whether mutually agreeable or not. The PRDA is silent on the applicability of the contractor's share of any increased or decreased cost attributable to such change.

In order to appreciate the magnitude of a potential loss, the following example is presented. Let us assume a 20 percent overrun was funded. Later on downstream a 15 percent overrun was not only evident but pointed out a technical challenge which the Government deemed formidable enough to terminate the program as a termination for convenience. The financial loss would be:

	Total	Government Share	Contractor Share
Basic	$10,000,000	$7,500,000 (75%)	$2,500,000 (25%)
Overrun (20%)	2,000,000	1,400,000 (70%)	600,000 (30%)
Total Loss	$12,000,000	$8,900,000	$3,100,000

There are some favorable aspects of the PRDA. The statement of work is prepared by the contractor and negotiated with the Government. Accordingly, the contractor should manage the program with a higher degree of control than if he simply proposed to a Government authorized work scope. In addition the contractor retains title to all purchased items of equiment in excess of $1,000.

Naturally, some other unfavorable aspects remain. For instance, the Government will get title to all subject inventions and a license to utilize background inventions.

There are many other items for consideration, but they apply generally to most cost reimbursement contracts rather than specifically to cost sharing arrangements.

Granted this memorandum demonstrated cost pessimism and lack of contractor control over a program which will cost the contractor, at the very least, 25 percent of the entire cost.

If the program had been accomplished by way of a cooperative agreement rather than a cost sharing contract, the arrangement would have been more favorable to the contractor.

If you need additional information, please contact the undersigned.

L. Costello

L. Costello

LC/pdc

ORGANIZATIONAL CONFLICT OF INTEREST/COST PARTICIPATION PRESENTATION

TO

JOHN SELLARS & STAFF

30 August 1984

E. J. McDonnell

OCI RELATIVE TO DEVELOPMENT WORK

DEAR 909.570-14

(a) In developmental work it is normal to select firms which have done the most advanced work in the field. It is to be expected that these firms will design and develop around their own prior knowledge. Development contractors can frequently start production earlier and more knowledgeably than can firms which did not participate in the development, and this affects the time and quality of production, both of which are important to the Government. In many instances, the Government may have financed such development. Thus, the development contractor may have an unavoidable competitive advantage which is not considered unfair and no prohibition should be imposed.

ORGANIZATIONAL CONFLICT OF INTEREST

If OCI present in proposed award, CO options:

- o Disqualify offeror
- o Mitigate by special clauses and/or conditions in contract
- o Seek a waiver
    - Secretary or Designee must determine award is in the best interests of the United States, i.e., Public exigency or Necessary work unobtainable from other sources
    - Must publish a record of D & F in Federal Register.

If OCI discovered after award:

- o Contract can be terminated or reformed
- o Contractor may be barred from future DOE work for non-disclosure or misrepresentation of disclosure facts
- o Criminal penalties are also possible (18 U.S.C. 1001) for willful concealment.

ORGANIZATIONAL CONFLICT OF INTEREST

Contractor OCI Disclosure and Certification Required for:

- o Evaluation services or activities
- o Technical consulting and management support services
- o Research and Development
- o Special situations.

If an OCI exists or may exist, no award can be made until mitigated or avoided.

Methods CO can mitigate if OCI present:

- o Special clauses which are negotiable
  - Hardware exclusion clauses
  - Software exclusion clauses
  - Clause to provide protection of proprietary or confidential data
  - Key personnel to avoid certain activities
  - Clauses to prohibit other segments of Contractor from being involved in the work.

OCI requirements flow down to subcontractors and consultants at all levels. ALSO Negotiable.

ORGANIZATIONAL CONFLICT OF INTEREST

DOE Legislative History Very Strong PL 93-275, 93-577, 95-91

Questions to ask:

- Are there conflicting roles which might bias a Contractor's judgement?
- Is the Contractor being given an unfair competitive advantage?

Examples or situations which might lead to OCI:

- Preparation of specifications for a subsequent competition
- Preparation of a detailed plan for specific methodologies
- Access to internal DOE information not available to public
- Access to Proprietary information
- Evaluation of your own products or those of another with a close business interest
- Providing technical advice or advice concerning regulatory matters that affect your products.

ORGANIZATIONAL CONFLICT OF INTEREST

DEFINITION: If, due to the nature of Government work, it

- o Results in an unfair competitive advantage to the Contractor

or

- o Impairs the Contractor's objectivity in performing the work (present or future).

Most likely to occur in contracts involving:

- o Management support services
- o Consultant or other professional services
- o Contractor performance in technical evaluations
- o Systems engineering and technical direction.

COST PARTICIPATION

DEFINITION: Generic term where Government does not fully reimburse Contractor's allowable costs on the program. Includes:

- o Cost Sharing
- o Cost Matching
- o Cost Limitation (direct or indirect)
- o Participation in kind.

No fee on cost participation contracts for prime.

Subcontractors may earn fee with CO approval.

COST PARTICIPATION CONTRACTS

APPLICATION: When DOE supports R & D:

- For commercialization
- Utilization in private sector
- Contractor to derive present or future economic benefits.

Mandatory for Demonstration projects unless exempted by the Under Secretary.
Others waived by cognizant Assistant Secretary.

Examples of Cost Participation:

- Cash outlays
- Real property or interest therein
- Personal property or services
- Cost matching
- Foregone fee
- In kind (non-cash, non-Federal sources).

MHD PROGRAM

DOE Approach:

- o POC for CDIF and CFFF

  OCI Concerns - HW Exclusion

  Cost Participation?

- o Retrofit Program

  No OCI concern if not involved in POC

  Cost Participation - Rationale.

DOE approach supportable by Law and Logic.

Mr. BOUCHER. Thank you, Mr. McElwain. We will be glad to hear from Mr. Fri.

STATEMENT OF ROBERT W. FRI, ADVISER TO THE BOARD, FUEL CELL USERS GROUP, WASHINGTON, DC

Mr. FRI. Thank you, Mr. Chairman. My name is Robert Fri and I am representing the Fuel Cell Users Group of the electric utility industry. If my testimony can be submitted for the record, I would like to just summarize a few points.

Mr. BOUCHER. Without objection, your testimony will be made a part of the record.

Mr. FRI. Let me just touch on a few points that I think summarize what I have to say. First of all, I think it's clear that the market wants the fuel cell. The Fuel Cell Users Group is an association of 56 utilities that have pursued the commercialization of fuel cells for 5 years, some of the individual members for more than 10.

Second, the progress in fuel cells has been good and it's been steady. Technical progress has been good, and most recently, large commitments to commercialization have been made. To give you a notion of the potential scope of those commitments, what it takes to go into business to produce and sell fuel cells is an amount of money greater than all of the research and development money thus far spent on the phosphoric acid fuel cells and it is money that is fully private and fully at risk.

Third, it is crucial that the technology pipeline not dry up now. Both the short- and long-term success of the fuel cell in the market, depend on continued technical development for some of the reasons Mr. Fuqua suggested in his observations on Mr. Mannella's testimony from the earlier panel.

Fourth, if anything, the Federal role in continued development is more critical now than ever precisely because the private sector is going to have a large amount of its own money at risk in this business of getting into business.

Finally, we therefore believe that now is not the time to cut back significantly on phosphoric fuel cell funding, much less to rescind 1985 funds as has been proposed by the Department of Energy.

That concludes my summary, Mr. Chairman. I would be happy to answer your questions.

[The prepared statement of Mr. Fri follows:]

STATEMENT ON THE FY 1986 FUEL CELL BUDGET OF THE DEPARTMENT OF ENERGY

Presented to the
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
of the
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. House of Representatives

Robert W. Fri
Advisor to the Board of Directors
of the
FUEL CELL USERS GROUP OF THE ELECTRIC UTILITY INDUSTRY, INC.
March 6, 1985

Mr. Chairman, I am Robert W. Fri, advisor to the Board of Directors of the Fuel Cell Users Group of the Electric Utility Industry, Inc. The Fuel Cell Users Group is an organization of 56 electric utilities including the national trade organizations of the electric power industry, the American Public Power Association, the Edison Electric Institute, and the National Rural Electric Cooperative Association, established to assist, promote and accelerate the development and electric utility application of phosphoric acid fuel cell technology.[1]

I thank you for this opportunity to present these brief remarks on the Department of Energy's FY 1986 budget.

The Fuel Cell Users Group, and my remarks today, are focused solely on the development and application of phosphoric acid, multi-megawatt fuel cell technology. We acknowledge the contribution that the gas industry's on site 40 kw program is making to technical knowledge, and we certainly appreciate the long term potential of the advanced fuel cell technologies, solid oxide and molten carbonate. We assert, however, that if phosphoric acid technology is not developed with advancements that makes it economically suitable for utility application, it is unlikely that fuel cells will be commercialized in this century.

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[1] The Fuel Cell Users Group of the Electric Utility Industry, Inc., is a five-year old organization with a membership of 56 utilities (and 10 associate members) spanning the privately, publicly, and cooperatively owned electric utility industry. A list of our membership is included as Attachment 1. Cumulatively, the members of the Users Group represent about 40 percent of the U.S. generating capacity. We are united in the interest of encouraging and supporting research, development, and demonstration leading to the ultimate commercialization of the phosphoric acid fuel cell power plant.

As this committee knows well, there are many reasons for the electric utility industry's interest in fuel cell technology. Its environmental attractiveness, fuel flexibility, efficiency and factory produced modularity have been described to you and your colleagues before. I also recognize that your committee fully understands the national benefits that could accrue if fuel cell power plants were commercially available. The strong support you and your colleagues have shown for the fuel cell over time is significant; without it we would not be facing the technical progress and the prospects for commercialization as we are today.

We are making significant progress. Approximately 2000 hours of operation by United Technologies Corporation's (UTC's) 4.8 MW power plant demonstrator in Tokyo confirms the technical feasibility of fuel cell electric generation. Regrettably, the Consolidated Edison demonstrator did not achieve full operation but the institutional and technical obstacles overcome by this first-of-a-kind plant made the Tokyo success possible and, together, these 4.8 MW experiences will provide the experience necessary to move toward commercialization.

Technical development progress is real, as well. UTC advancements in producing larger cell stack assemblies with the technical characteristics likely to lead to acceptable product capital cost and operating cost are encouraging. Westinghouse progress in achieving cell stack performance objectives and in completing a preliminary system design are proof of the potential for this concept.

Progress in commercialization of fuel cell technology, the real objective of the entire effort, is drawing increased attention from the Users Group. We are encouraged by the business relationships being established by UTC and Westinghouse which will increase their capability to engineer the product and serve the market. The increasing Westinghouse corporate investment is further measure of commercial progress.

Unfortunately, it is easy to misinterpret this progress and assume, as the Department of Energy must, that the technology is commercially ready for private support alone. It is not! The cost and performance targets set several years ago have yet to be reached, or proven reachable. There is a lot of very basic information that is still needed by the technology developers and by utilities. As the January 17, 1985 report by the Congressional Research Service, Fuel Cells for Electric Power Production: Future Potential, Federal Role and Policy Options states:

> "There are some uncertainties about whether fuel cells can achieve technical, performance and cost objectives. Although technical and operational feasibility have been established, there are still concerns about water purity, durability, heat rates and alternative fuel use that may be difficult to attain."

Beyond the technical objectives to be met for commercial introduction, continued reliability, efficiency and cost improvements are necessary for significant penetration of this new technology. It is the promise of continuing improvements that will encourage buyers of early prototypes to take the extraordinary business risks they will be taking. These longer term, higher risk improvements are the subject of an October 12, 1984 letter from the Users Group to Assistant Secretary Vaughan, This letter (Attachment 2) provided an outline of the Users Group's technical development priorities.

In addition to listing priorities for technology development, the Users Group letter encouraged DOE to formulate and fund a program aimed at verifying the option of using coal as a fuel for fuel cell power plants. Although industry and the public sector need to complete the development and commercialization of the power plant with a conventional steam reformer, the interests of the country are better served if coal becomes an option. The fuel cell is highly efficient, but there is a certain amount of engineering, gas clean-up equipment and testing necessary to expand fuel flexibility through coal gasification. In its February 13, 1985 statement (Attachment 3) to the Department of Energy's request for clean coal technology information proposals, the Users Group recommended that projects designed to test the compatability of these two technologies, coal gasification and fuel cells, be funded.

The long term potential for clean coal use, the minimal environmental impact and the unique efficiency, modularity and rapid construction characteristics have historically warranted fuel cell support by this committee. Interest in expanding domestic coal use for electric generation and concern for acid rain should only increase the need to continue the support.

Judging when public support can end, for a product nearing commercial application, is a difficult task. Tempting though it may be, we believe that it would be very risky for the federal government to significantly reduce its commitment at this time. These multi-dimensional utility/manufacturer/EPRI/federal programs require each party to fulfill its commitment. Although the private sector has shouldered two-thirds of the financial burden of fuel cell development, the federal government has a significant stake in the program which is in jeopardy. Withdrawal of support this far ahead of commercial success will probably push wide spread application of the technology beyond the year 2000, and possibly even create an insurmountable gap. Improvements still to be achieved will significantly broaden the application and benefits of the technology, including possible baseload applications utilizing coal. If the benefits of past federal support are to be realized in the near future, careful attention to funding requirements is necessary to avoid loss of momentum at a critical period.

Mr. Chairman, last year's FY 1985 funding levels of approximately $22 million for electric utility phosphoric acid fuel cells, $30 million for all of the phosphoric acid program, was appropriate. The DOE recommendation that $4.9 million of this should be "deferred" is inappropriate and should not be approved.

The Users Group recommends that FY 1986 support be continued at the FY 1985 levels noted above. Concurring with this, I note the National Rural Electric Cooperative Association Resolution No. J-4, Attachment 4, which advocates a "five-year commitment for fuel cell reseach and development. The potential of this technology is yet to be realized."

Mr. Chairman I thank you and the Committee for your sustained interest in this attractive technology. I encourage your continued support. I'll be happy to respond to any questions or comments on these remarks.

ATTACHMENT 1

FUEL CELL USERS GROUP

MEMBERS

Federal Government Utilities

Bonneville Power Administration
Tennessee Valley Authority

Cooperatives

Adams Electric Cooperative, Inc.
Allegheny Electric Cooperative, Inc.
Buckeye Power, Inc.
Colorado-Ute Electric Association, Inc.
Lee County Electric Cooperative, Inc.
National Rural Electric Cooperative Association
Orcas Power & Light Company
Southern Maryland Electric Cooperative
United Power Association

Municipals

American Public Power Association
Anchorage Municipal Light & Power Department
Arkansas River Power Authority
Austin Electric Department
The Easton Utilities Commission
Jacksonville Electric Authority
Lincoln Electric System
Los Angeles Department of Water & Power
Memphis Light, Gas & Water Division
Missouri Basin Municipal Power Agency
Omaha Public Power District
Palo Alto Electric Utility
Provo City Power Department of Utilities
Salt River Project Agricultural Improvement & Power District
Santa Clara Electric Department
Taunton Municipal Lighting Plant

Investor Owned Utilities

Boston Edison Company
Central Hudson Gas & Electric Corporation
Central Illinois Light Company
Cleveland Electric Illuminating Company
Consolidated Edison Company of New York, Inc.
The Dayton Power & Light Company
Delmarva Power & Light Company
Duquesne Light Company

Investor Owned Utilities (cont.)

Edison Electric Institute
Green Mountain Power Corporation
Hawaiian Electric Company, Inc.
Idaho Power Company
Kansas City Power & Light Company
Mississippi Power & Light Company
Niagara Mohawk Power Corporation
Northeast Utilities Service Company
Northern States Power Company
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Philadelphia Electric Company
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Public Service Company of Oklahoma
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Hydro-Quebec

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The National Commission for Research & Development of Nuclear Energy & Renewable Energy Sources
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Johnson Matthey Research Centre
Kinetics Technology International Corporation
New Energy Development Organization
NUS Corporation
Stone & Webster Engineering Corporation

ATTACHMEN 2

THE FUEL CELL
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[illegible]

October 12, 1984

Mr. William A. Vaughan
Assistant Secretary for
Fossil Energy
Room 4G-084
Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Bill:

Following up my May 18, 1984 letter to you, I present to you the Fuel Cell Users Group's views on the need for a sustained federal technology development program in support of phosphoric acid fuel cell power plants. These views, approved by our Management Committee, are attached.

The electric utilities strongly desire not only that the present fuel cell technology be brought to commercial application on their systems, but also that the full electric generation potential of this chemical conversion technology be reached through continued technical development efforts. It will not be sufficient to see the first prototype commercial article leave the factory loading dock.

The Users Group provides a mechanism for a large number of utilities to consolidate their needs as prospective buyers of fuel cell power plants. Although such a mechanism is extraordinarily useful, it does not always operate quickly, especially when dealing with issues as important as the one you posed. Furthermore, because the Users Group's role is to consolidate utility needs, it does not (and should not) prescribe specific development tasks for the manufacturers and others to undertake. These latter organizations have both the responsibility and expertise to determine how best to meet the needs expressed by the potential customers.

Thus, while the attached views are not a task-specific set of recommendations, I believe they are the more important for the clarity of the unmistakable objectives they set forth. And if this process has taken more time than I might have hoped, these views carry the weight of thorough and careful consideration by our Management Committee.

Thank you for your consideration of the industry's views.

Sincerely,

Bob

Robert W. Fri
Advisor to the Board

RWF/tc
Enclosures

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[illegible]
Chairman & Chief Executive Officer
[illegible] Gas & Electric Company

[illegible]

[illegible]
[illegible]
[illegible]
[illegible] Technologies Corporation

CONTINUING FEDERAL FUEL CELL SUPPORT

The Management Committee of the Fuel Cell Users Group of the Electric Utility Industry has considered the need for continuing federal support of the phosphoric acid fuel cell for electric utility applications. In doing so, we have taken into account:

1. EPRI's continuing program of research and development in this area.

2. EPRI's readiness to provide significant financial support to the manufacturers' commercial prototype program.

3. The need for the electric utility industry to purchase prototype and early commercial units. In this connection, we note that the Southern California Edison Company has recently contracted with Westinghouse to initiate a prototype program, and that United Technologies Corporation is about to begin its marketing effort.

4. DOE's policy for conducting energy research and development.

Finally, we have considered the growing interest in fuel cells on the part of our industry, arising in large part from the increasingly apparent need for efficient, modular, and environmentally acceptable generating technology.

Westinghouse

Westinghouse has developed a balanced program for development and deployment of fuel cell power plants. Although this program relies heavily on DOE and EPRI funding in its development stage, Westinghouse and utility financial commitments are closely integrated with development milestones. We urge DOE to continue its support of this program, and to manage its support in a way that recognizes the balance of the program and the needs of all the parties.

United Technologies Corporation

United Technologies Corporation is preparing to design and fabricate its early commercial fuel cells, and, through a joint venture, intends to fund this work. However, we believe that this early commercial design can and should be improved. Specifically, we believe that:

1. A significant improvement in heat rate is possible in phosphoric acid technology by pursuing known technological paths.
2. Cost reduction through design and manufacturing process improvements can be attained.
3. Either or both of the above advances would greatly increase the use of fuel cells in electric utilities. Our studies suggest that such advances could easily double the size of the market.

For these advances to occur, it is essential that the technology pipeline not dry up as UTC and the electric utilities focus their resources on deploying early fuel cells. We therefore urge DOE to continue its support of:

1. Technology advances that can be incorporated as engineered improvements in units deployed after market entry.
2. Riskier cost reduction efforts that the manufacturer is unable to undertake in the design of the early commercial units which, above all, must display successful operation.

Recommendations

We believe it is essential to verify the option of using coal as a fuel for fuel cells. While the need for deploying this option will be determined by future fuel price and availability, it is clear that many utilities see it as essential for widespread use of fuel cells. We encourage DOE to support the formulation and funding of a program toward this end.

DOE should continue to support its program commitments under present plans with the vendors. DOE should also support technology development that will provide the basis for improvements that can be engineered into future fuel cell power plants. Technology support is consistent with DOE's research objectives and will have a substantial impact on the utility industry's acceptance of this fuel-flexible, environmentally sound technology. An outline of technology development priorities follows:

1. The top development priority is to improve the fuel cell stack performance, fabricability and cost. Federal support of comprehensive and coordinated efforts to enhance the development of the base technology, to improve upon material and component development options, and to further improve efficiency and corrosion resistance are required.

   - The primary developers of fuel cell power plants, the manufacturers, need continuing fundamental research capability (either in-house or through license or contract) as a base for their development programs and to develop improvements in their products. The primary manufacturers also need support beyond the point where they have verified their technology in cell and stack tests. There are thousands of individual fuel cells in a power plant, so the capability to mass-produce quality components economically is an inherent requirement of the development effort. Developing this capability is a costly and risky task due to its impact on the large investment required for production tooling, the long lead time for developing production techniques, and the chances that production cost targets and anticipated market levels will not be reached. This transfer of the technology from the laboratory to the production line faces both UTC and Westinghouse now; continued federal support throughout this transfer phase is critical for success by either party.

   - Support for materials and component development is also required. Secure sources of these items, meeting the specifications of the manufacturers at competitive prices, are required. This is a continuing concern to the manufacturers as several times in the past the loss of a vendor, or a change in their product, has caused major upheavals in the technology. This material and component development appears to be proceeding particularly well in the Japanese Moonlight Program and we feel this is partly responsible for their rapid progress.

   - Continued support of research and development in areas such as catalysis, catalyst supports, kinetic and reaction studies, corrosion studies, etc., will lead to the 7-10% improvement in heat rate that we believe can be achieved in the near future.

2. Federal support is also important in the development of fuel processing technology. Conventional catalytic steam reforming as used in the petrochemical industry does not meet utility power plant needs. To meet the cycling duty, variable power and other requirements unique to power plants requires major engineering changes to this process equipment. In the near term, the effort should focus on engineering development of process equipment to use natural gas and light distillate fuels. We also suggest that some effort be sustained to explore the use of industrial by-products and renewable resources as fuels, where market studies show adequate fuel supplies and benefits. Efforts should be initiated to couple the fuel cell to coal gasifiers as this option has great potential to use coal more efficiently, with lower emissions, in smaller, modular plants, compared to other technologies. This fuel processing technology may also have major spin-off benefits in petro-chemical and other industries through more efficient use of feedstocks and reduced construction material requirements.

3. We believe that the development of system controls and ancillary components has not received sufficient emphasis to date. This is a generic problem in the advanced energy technologies; the developer tend to "make do" with available controls and components to minimize program costs, with the all too common result that the technology demonstrations are compromised by the poor performance and reliability of controls and ancillary equipment. This was certainly one of the major reasons for the delays in the New York 4.8 Mw demonstration project as well as the shortcomings experienced in demonstrations of other technologies. This is an area of work that requires significant funding to perform well because subsystems and systems must be built at reasonable scale to verify the controls and components. It is unlikely that the developer will devote much of its own resources to this (especially if the project is marginally funded) since its priority is on the higher technology items. We strongly suggest that DOE consider increasing their support in this area. We suspect that it may, in fact, be cost-effective to do so because it will yield better quality technology field tests and reduce expedient fixes and the consequential delays in these activities.

4. We recommend that modest support of power conditioning technology be continued. The state of the art in power electronic devices is progressing rapidly. These ad-

vanced devices should be factored into the dc to ac power conditioning equipment to improve system reliability and cost, but more importantly, to verify overall system control as listed in paragraph 3 above.

Summary

Federal support of fuel cell development is important if the program is to attain the benefits that this technology can provide. The development of the fuel cell power plant will be severely delayed, if not halted, if support is curtailed too early.

ATTACHMENT 3

THE FUEL CELL
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President

Robert W. Fri
Advisor to the Board
Jeffrey A. Serfass
Executive Director
Energy Transition Corporation

February 13, 1985

Mr. Jack S. Siegel
Deputy Director
for Coal Utilization,
Advanced Conversion and Gasification
Department of Energy FE-20
Washington, DC 20545

Dear Mr. Siegel:

The Department of Energy has requested information proposals for projects employing clean coal technologies. One of the technologies to be considered in this program is "phosphoric acid fuel cell systems using coal derived gas."

The Fuel Cell Users Group is an organization of electric utilities formed with the objective of promoting and assisting the development and commercialization of fuel cell power plants. As such, we cannot respond to your solicitation with a proposal for a specific project. We understand, however, that you will receive several proposals for fuel cell - coal gasification projects.

The Users Group and its members strongly advocate that funds be requested specifically for such projects in the clean coal technology program. The Management Committee of the Users Group has unanimously approved a statement to this effect. A copy of the statement is attached, and we trust it will become part of the record on which subsequent program decisions are based.

If you require any further information, please contact me.

Sincerely,

Jeffrey A. Serfass

Jeffrey A. Serfass
Executive Director

JAS/tc
Enclosure

STATEMENT ON COAL GASIFICATION WITH FUEL CELL POWER PLANTS

by the
Management Committee
of the
Fuel Cell Users Group of the Electric Utility Industry, Inc.,

The Fuel Cell Users Group of the Electric Utility Industry, Inc., is a self-supporting organization of 55 electric utilities and 11 associate members. Formed in 1980, the Group's purpose is to promote, accelerate, and assist the commercialization of multi-megawatt phosphoric acid fuel cell power plants. The Users Group represents all segments of the electric utility industry: investor-owned, municipal, rural electric, and federal power systems.

The commercialization of fuel cell technology is important to the electric utility industry. The technology is efficient and environmentally attractive. Because fuel cells are modular and factory-manufactured, they will reduce financial burdens on utilities and their ratepayers. They are environmentally siteable and technically suitable for cogeneration applications and are thereby able to achieve an overall efficiency of 80 percent with the use of by-product heat. And, as noted below, this technology does not require utilities to rely on gas or imported oil as fuels. The fuel cell option must be available to the industry in the 1990s to fulfill anticipated needs for new capacity.

Early commercial fuel cell power plants now being developed, according to the Users Group's Fuels Subcommittee, will use natural gas as the preferred fuel; both technical and economical considerations lead to this conclusion. However, much of the industry is seeking to avoid the use of natural gas and other premium fuels for power generation in future capacity additions. Premium fuels carry greater risks of diversion to higher priority uses, of rising prices and of political intervention.

Fuel cell technology is well-suited to the use of coal-derived and other alternative fuels. Fuel cell commercialization is occurring at a time when increased use of coal for the generation of electric energy is a common objective. The clean use of coal can be increased in cogeneration applications and in repowering of existing but old urban power plant sites with the non-combustion characteristics of fuel cell electric generation. Thus, it is appropriate that the electric utility industry seek to establish coal as a fuel for fuel cells early in the commercialization process. Doing so would significantly increase the use of this environmentally benign technology.

Through the Electric Power Research Institute and other programs, the industry is already pursuing the objective of having this combination of technologies available in the 90's when it is needed. Studies suggest that early fuel cell power plants could be modified and coupled with small, commercially available coal gasifiers to produce an economical power plant based on coal today. As fuel cell technology matures, even more attractive ways to use coal with fuel cells appear possible.

The Fuel Cell Users Group urges DOE to recommend to Congress that the federal government participate with utility and manufacturer testing of coal gasification with fuel cell power plants as early as practical. While actual timing of this effort will depend upon the availability of early commercial fuel cell power plants, it requires consideration now as to the technical and engineering requirements. Any projects developed by the Department of Energy and funded by Congress must involve the participation of one or more electric utilities, the eventual users of this combined technology option.

The Department of Energy has already provided significant support to the development of phosphoric acid fuel cell technology. As private industry continues to increase its commitment to commercialization of the basic power plant, it is appropriate for the federal government to allocate resources to the use of our most abundant fuel, coal, with the power plant.

The Fuel Cell Users Group and its broad representation of the utility industry stands ready to assist in any way it can, from helping to shape plans for any resulting program to helping to evaluate alternatives.

ATTACHMENT 4

NRECA Annual Meeting 1985

RESOLUTION NO. J-4

FROM: Research and Technological Development Committee
APPROVED BY: Resolutions Committee

SUBJECT: Research for Electric Power Self-Sufficiency and National Security

We support a well-funded, long-range commitment both for fuel cell development and for Electric Energy Systems (EES) research and development. These areas have national security implications as well as the potential for providing opportunities for energy self-sufficiency.

We therefore urge the Administration and Congress to provide the following:

1. A five year commitment for fuel cell research and development. The potential offered by fuel cell technology for highly efficient, dispersed electric power generation (so essential to national security) is enormous. Along with the potential economic advantages, the fuel cell has other very desirable characteristics--i.e., environmentally benign, short lead time for installation, modular design, and favorable load-following capabilities--which make it truly a power source worth developing and commercializing.

2. Minimum funding of $30 million for FY 86, along with adequate staffing, for Electric Energy Systems research within the Department of Energy. EES is involved with several programs of critical national importance.

   * Among them is the study of the effects of electromagnetic pulse (EMP) which, in the event of a strategic military weapon explosion in the atmosphere, could result in a pulse from gamma rays that could create an electric system surge from 10 to 100 times faster than a lightning stroke. Such a pulse could disrupt nationwide communications and immobilize the entire electric industry.

   * Other EES projects which require strong support include system technologies for improving efficiencies and reliability of power generation, transmission and energy storage, and the electric field effects of high voltage transmission lines.

Mr. BOUCHER. Thank you, Mr. Fri. We will have some questions for you after we've heard from the other panelists. We will be glad to hear from Dr. Solomon.

STATEMENT OF DR. PETER R. SOLOMON, PRESIDENT, ADVANCED FUEL RESEARCH, INC., EAST HARTFORD, CT

Dr. SOLOMON. Mr. Chairman, I am here representing the American Chemical Society and the chairman of the fuel chemistry division of the American Chemical Society. The ACS is the largest professional organization of chemists and chemical engineers, with over 135,000 members. I'm sure most of you don't know about the fuel division. We are about 1,000 members, but the fuel division is the largest organization of scientists in the United States working in fuel science.

The ACS Board of Directors has authorized me to appear before you today to present the society's position and recommendations concerning the support of alternative fossil fuels research.

What I would like to do is simply highlight a few of the points from that record in my role as representing the ACS and then I would like to step out of that role and present some observations from the perspective of an active researcher in coal science.

Many of the points that we've made in the statement have been made before in terms of the need to provide usage of coal over the future. The first point that I would like to make is that in order to utilize these resources—coal, oil shale, tar sands—effectively, we really need a continuous long-range stable R&D program. That is a fine motherhood statement and everyone accepts that. The question is, why do we need this, and I would like to just expand a little bit on why.

At the present time, we do not have sufficient understanding of the basic chemical reaction in coal processing to make good predictions of processes. This is one of the reasons why we speak, and Mr. Fuqua spoke, of the problems of scale-up. This is one of the underlying causes for our lack of good predictive capability in scale-up. We don't have a good handle on a lot of the fundamental reaction kinetics.

With this situation of a lot of work to be done, we have an unfortunate situation and that is, this abundance of oil has let to the cutback of many of the research efforts. The fossil energy program in the Department of Energy has been cut back. What is more severe is a sharp cutback in industrial support in fossil energy. I will expand on that point in my personal remarks.

The third point is that it is really unfortunate timing that these cutbacks occur today. We have gotten a lot of momentum going in coal science of other alternative fossil fuels. We've brought in new people with new perspectives into this area. We've brought new scientific tools to bear on the problem. We have now the availability of very large computers to handle some of the very difficult calculations and we are making a lot of progress. But that progress has not brought us to the point of being able to make good reliable predictions of the way these fuels will behave in a process.

With the cutbacks that we're looking at now, this progress is going to be severely limited. The ACS would like to propose that we must maintain a critical mass of scientists working in this area if we're going to continue progress and we've proposed a strategic fossil fuel scientific and engineering reserve and, by this we mean, we've got to supply a certain level of support to maintain a minimum science in this area; a minimum community of experts working on fuel science and applications. In order to insure that we do have this minimum support, the ACS has recommended that the budgets for the long-range R&D—the particular budget items are listed in the written statement—be increased from the current request for $34.4 million to $70 million. We also recommended that the remainder of the fossil energy budget be maintained at or above the fiscal year 1985 level.

I think that a consideration should be given to taking some of this money from the clean coal technology reserve as some of the basic R&D has to be done with regard to the basics of the way the pollutants are in the coal.

Let me step out of my role as representative of ACS and just highlight two of the points.

First, our level of understanding is presently inadequate and to illustrate this point, I want to consider coal combustion. We take a particle of coal and throw it into a combustor and all of the basic phenomenon are in controversy in terms of the way they happen, we cannot predict the amount of time and the rate at which the coal heats up to temperature. We cannot predict the amount of coal that becomes volatile. We don't know where the ignition occurs. We don't understand the mechanisms of soot formation. We cannot predict the reactivity of the char and so the time the char takes to burn out. All of the basic problems of predicting the way a coal conversion device—we have inadequate knowledge of the basic reactions and rates for those reactions.

If we had accurate computer modeling which incorporated accurate chemistry of these materials, the cost for designing processes would be drastically reduced. We would not have to take every different coal and subject it to full-scale testing as possible to prove out a process. We would have a much better way of designing our processes.

The final point I would like to address is the industrial community—this is a question that was raised by Mr. Packard—what is the overall level of support? Is it going up or is it going down? I tried to get information on this question. I called friends at various large industrial organizations that had traditionally been spending a lot of money in coal sciences. The results of that limited survey—but I did talk to the 10 largest organizations in the United States that were putting money into this—were very dismal. That is that within the last few years from the peak to the present time, we are looking at something in excess of 500 positions of coal scientists that are now no longer being supported industrially with a price tag of something between $60 and $70 million that is not being invested by the private sector in coal research. That is a very significant fraction of the amount of money that was spent 3 years ago in fossil fuel research.

We have a window now of opportunity to provide a sound foundation for designing processes in the future when we really need them and it would be a shame to waste that opportunity.

Thank you for allowing me to present these views.

[The prepared statement of Dr. Solomon follows:]

STATEMENT

of

DR. PETER R. SOLOMON

on behalf of the

AMERICAN CHEMICAL SOCIETY

to the

SUBCOMMITTEE ON ENERGY DEVELOPMENT & APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

on the

DEPARTMENT OF ENERGY FY 1986 FOSSIL ENERGY BUDGET

WEDNESDAY, MARCH 6, 1985

Mr. Chairman and Members of the Subcommittee:

My name is Peter R. Solomon. I am Chairman of the Division of Fuel Chemistry of the American Chemical Society, and I appear before you today with the authorization of the Society's Board of Directors.

The American Chemical Society, a nonprofit scientific and educational organization with a membership of over 135,000 chemists and chemical engineers, is concerned about the diminishing government support of research in alternate fossil fuels at a time when continued progress in this area is essential to the long-term security, economic health, and environmental well-being of the United States. The ACS recommends that present government support for alternate fossil fuel research be substantially increased. The commitment of adequate and stable funding is necessary to support a "strategic fossil fuel scientific and engineering reserve," a minimum community of experts dedicated to building a strong U.S. high technology base for utilizing U.S. supplies of coal, oil shale, and tar sands. The existence of such a technology base is needed to expand the present use of these alternative fuels and thus extend the life of oil and gas supplies for premium usage. This technology base would serve to minimize the economic and environmental impacts of a transfer to these alternative fuels in the event of a foreign oil supply cut-off or the more gradual, but inevitable, decline in oil supplies.

While today's oil supplies appear to be plentiful, a recent report from the Office of Technology Assessment prepared for the Senate Foreign Relations Committee concluded that a disruption of foreign supplies "could still have significant consequences for the U.S. economy." The Annual Report of the American Petroleum Institute projects that even without a disruption of foreign supplies, oil shortages could develop within the next fifteen years if economic conditions continue to improve. The utilization of the vast U.S. reserves of coal, oil shale, and tar sands to provide liquid fuels, either by conversion to liquids or by an oil-substitution strategy, represents the best solution to reduced oil supplies for at least the next fifty years.

To utilize these resources properly, stable, continuous long-range R&D programs are needed to provide a sound, high technology foundation on which to select and implement the process alternatives in a cost effective and environmentally safe manner. Continued effort is badly needed on the basic chemical structures and reaction chemistry of coal, oil shale, tar sands, coal minerals, and polluting species (soot, SO_x, NO_x, polyaromatic hydrocarbons, etc.). Significant process improvements could also be made by advancing catalyst technology.

Unfortunately, the present abundance of oil, the duration of which is uncertain, has led to the dismantling of many alternative fossil fuel research efforts. The U.S. Department of Energy has cut its FY 1986 budget request for Fossil Energy to $243 million compared to $347 million appropriated in FY 1985. The budget line items that support long-range research have been reduced from $43.5 million appropriated in 1981 to $34.4 million requested for 1986. Similarly, major industrial organizations have cut back substantially on their research activities in alternative energy sources because, under the present circumstances, utilization of such efforts is perceived to be too far in the future. At the present levels of support, it will be difficult to maintain sound technical expertise and adequate training of new scientific and engineering talent in the technologies of coal, oil shale, and tar sands. Unless corrected, this situation will jeopardize the ability of the U.S. to respond effectively to another oil shortage.

It is indeed unfortunate that these cutbacks come at a time when the opportunities for advances have never been greater. The status of research on coal, oil shale, and tar sands today may be compared to that of biochemistry fifty years ago. In the case of biochemistry, the application of new scientific tools expanded the basic understanding of biological systems, eventually leading to the revolutionary technology of genetic engineering. Today new spectroscopic techniques, chemical procedures, and theoretical understanding are available to probe the structure and reactions of non-crystalline solids. New, in-situ diagnostic tools and computer modeling techniques are being advanced for accurate determination of process behavior. A great potential exists for rapidly developing new knowledge that could lead to revolutionary high technology processes for utilizing these solid feedstocks in an environmentally safe and cost effective manner.

The inevitable reliance on coal and other alternative fuels calls for the maintenance of a "strategic fossil fuel scientific and engineering reserve." The stable maintenance of such a "reserve," a minimum community of experts in fossil fuel science and application, will greatly improve the scientific and technological foundation needed to make implementation decisions, to design improved plants, and to train personnel. The motivation for maintaining such a "reserve" is based on considerations of national security, goals for the environment and the long-range economic health of our Nation, which are all federal government concerns. Given the drastic reduction in industrial R&D in the alternative fossil fuel area, the continued erosion in federal government support will have a significant negative impact.

To insure the maintenance of an adequate and stable R&D program in alternative fossil fuels research the ACS recommends that the FY 1986 Fossil Energy budget items for long-range research be increased from the requested $34.4 million to $70 million. These Fossil Energy budget items include direct utilization, materials, university coal research, coal liquefaction advanced research, and surface coal gasification advanced research. Also, the remainder of the fossil energy budget should be maintained at or above the FY 1985 levels to insure that the research results can be tested on an appropriate scale. It is further recommended that $2 million be added to the Chemical Sciences part of the Basic Energy Sciences budget proposal to be used for chemistry related to coal and other fossil fuels. This addition to the Chemical Sciences budget is part of the $22 million increase previously recommended by the American Chemical Society in its July 23, 1984 letter to then Secretary of Energy, Donald P. Hodel (copy attached). The recommended levels should be maintained in future years to provide stability in research efforts.

Furthermore, it is recommended that the budget for long-range fundamental research and development activities should not be transferred to more short-range special projects. Consideration should be given to utilizing the "Clean Coal Technology Reserve," recently set aside from the Synthetic Fuels Corporation to provide some of this needed funding. Finally, to insure that funding decisions are based on adequate input from the research community, it is recommended that a significant portion of funding be awarded on the basis of peer reviewed proposals.

The American Chemical Society appreciates the opportunity to express its views on this issue. The costs of these recommendations would be small compared to the potential benefits derived in helping to insure a stable, long-range energy supply in the U.S. and to reduce our vulnerability to the uncertainties in foreign oil supplies. The ACS looks forward to continued federal support for the important research that is being conducted in the alternate fossil fuels program.

ACS 84-014

American Chemical Society

OFFICE OF THE
PRESIDENT

Warren D. Niederhauser
President-Elect 1983
President 1984
Immediate Past President 1985

1155 SIXTEENTH STREET, N.W.
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July 23, 1984

The Honorable Donald P. Hodel
Secretary of Energy
U.S. Department of Energy
Forrestal Building, Rm. 7A-257
1000 Independence Ave.
Washington, D.C. 20585

Dear Secretary Hodel:

The American Chemical Society, a nonprofit scientific and educational organization with a membership of over 130,000 chemists and chemical engineers, would like to point out the significance of chemistry to a healthy U.S. economy. Chemistry accounted for $175 billion of the gross national product in 1982, and also made a $12-billion positive contribution to our trade balance.

We note that in recent years the research-supporting part of the Chemical Sciences budget has not kept pace with opportunities inherent in today's progress in chemical understanding. Therefore, the Society urges that, as a step in the direction of making better use of advanced, energy-related opportunities in the Chemical Sciences, the Department of Energy increase by 25% the total of funds sought for operating and capital equipment in its FY 1986 budget request. This $22-million increase should be designated to support research in chemical catalysis and understanding chemical reactivity. A large fraction of the increase, up to one-half, should be used to obtain the advanced instrumentation that is essential to the most meaningful research.

In the generation of energy, chemistry plays vital roles now and offers some excellent opportunities for cost-effective future advances. A few examples underscore this point.

Catalytic manipulation of petroleum fractions now allows adjustment of product mix to market conditions. Scientists and engineers engaged in basic and applied research have begun to open new doors to catalytic, step-wise conversion of coal into fuels like methanol and gasoline.

Basic research using advanced instrumentation has begun to throw light onto the fast and complex chemistry of combustion. Such developments raise the hope and expectation that an understanding of the underlying phenomena will allow tailoring of fuels and combustion conditions to one another for best efficiency of fuel use and the least generation of pollutants (e.g., soot).

Chemical scientists involved in basic research using advanced instruments are slowly penetrating the subtle chemical geometries and reactions whereby chlorophyll gathers sunlight and uses its energy to split water in the early steps of photosynthesis. The field of photoelectrochemical production of hydrogen is one that has experienced significant progress over the past few years. Basic feasibility studies indicate that the area could have real promise with respect to DOE objectives. It is likely that we shall see substantial progress in this area in which intense activity is occurring among some very talented scientists, both in industry and within universities.

The modern instrumentation that makes possible this kind of progress in energy-related understanding is based on sophisticated techniques and, is more expensive than the chemist's tools of only a decade ago. Typical of the new techniques are: picosecond spectroscopy, spin-echo electron spin resonance, photoelectron spectroscopy, and Fourier-transform spectrometry--as well as the use of lasers, molecular beams, and computer-based experimental control and data analysis. These and other advanced techniques can provide exciting new insights into chemical phenomena, which will inevitably lead to further advances in energy technology.

The ACS is in agreement with the panel members of the National Academy of Sciences who have identified three areas of chemistry having the greatest promise, two of them intimately related to energy. These two areas--understanding chemical reactivity and chemical catalysis--have much to offer for energy security, a healthier energy marketplace, international trade competitiveness, and future U.S. needs.

Sincerely yours,

Warren D. Niederhauser

Warren D. Niederhauser

cc: Dr. A. W. Trivelpiece
Dr. J. S. Kane
Dr. R. H. Kropschot
Dr. E. S. Pierce

Mr. BOUCHER. Thank you, Dr. Solomon. We will be glad to hear from Mr. Hart.

STATEMENT OF S.R. HART, JR., VICE PRESIDENT, SOUTHERN CO. SERVICES, INC., BIRMINGHAM, AL

Mr. HART. Thank you, Mr. Chairman. My name is S.R. Hart, Jr. I am vice president, research and development of Southern Co. Services, Inc., Birmingham, AL. I appreciate very much the opportunity to testify today in support of the Wilsonville Advanced Coal Liquefaction Research and Development Facility and to request the addition of $6.5 million to the Department of Energy's fossil energy budget for fiscal year 1986 to continue operation of this very important pilot plant for 1 final year.

The Department of Energy and the Electric Power Research Institute provide funding for the operation of Wilsonville. Southern Company Services is the prime contractor to both of these organizations, and Catalytic, Inc. is our subcontractor for operation of the pilot plant. The annual operating budget is approximately $10 million and current employment is 122 people.

I have prepared formal testimony which has been submitted in accordance with instructions from your staff. I hope that each member of this distinguished committee will have the opportunity to read this five-page statement which discusses in detail the justification for continuation of Wilsonville.

Mr. BOUCHER. Without objection, that statement will be made a part of the record.

Mr. HART. Of more immediate major concern is the continued operations of Wilsonville beyond the end of this month due to the proposed deferral by DOE of $4 million of approved fiscal year 1985 funds.

The DOE maintains that proof-of-concept has been achieved at Wilsonville and that further development should be the responsibility of the private sector.

I assume that proof-of-concept refers to the general level of conversion of coal to liquid product. By this measure we have demonstrated at Wilsonville, that the fully integrated two stage liquefaction process is the most efficient and promising of several direct liquification processes. However, we have not developed a sufficient data base for a range of coals that could support scaling the process up to a large demonstration or pioneer commercial plant. Thus, I feel that for DOE to stop at proof-of-concept is to leave too many unanswered questions to expect the private sector to complete the pilot plant mission.

I hope that this committee will reaffirm its support for Wilsonville as expressed last year and help to deny this deferral request so that we may meet our commitments to you.

Back to the matter of fiscal year 1986 funding, basically there are two major reasons for continuing the Wilsonville program. These are first, to improve the fundamental understanding of the mechanism of direct coal liquefaction; and second, to complete the development of a data base that can be used by industry to design commercial plants when economics permit. The second reason is the most important because the Wilsonville facility is the only existing pilot plant that can provide such data.

My testimony also identifies major objectives we expect to reach by the end of 1986 and unless there is a drastic change in the nation's outlook for oil, the plans for Wilsonville will include completion of the important work currently underway followed by an orderly shutdown of the facility at the end of 1986.

Wilsonville is an outstanding example of successful joint research sponsorship by Government and the private sector. The approximate amount of funds provided by the participants through 1984 were $48 million by the Government and $37.7 million by the private sector. If the program is terminated before completing the remaining objectives, many of the potential benefits from this investment will be lost. The Electric Power Research Institute is planning to provide $6.6 million for 1985 and 1986 to continue its share of this project. Southern Company Services is committed to continue to provide project management at no cost to the Department of Energy and the Electric Power Research Institute.

At Wilsonville, we have a highly trained and capable technical and management organization which provides a firm capability for assessing the potential of two-stage liquefaction technology. Current programs through 1986 would advance this technology to a state of readiness for commercial application which could have very large benefits in the event of disruptions to current oil supplies. In other words, we consider this to be a very important insurance policy in our long term energy supply picture.

I thank each of you for your attention and respectfully request that you consider the merits of this proposal and weigh the very real benefits which can be derived from continuation of the coal liquefaction research program at Wilsonville, to completion in 1986.

[The prepared statement of Mr. Hart follows:]

TESTIMONY BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
UNITED STATES HOUSE OF REPRESENTATIVES

MARCH 6, 1985

WILSONVILLE ADVANCED COAL LIQUEFACTION RESEARCH AND DEVELOPMENT FACILITY

By

S. R. Hart, Jr., Southern Company Services, Inc.

Introduction

Thank you. My name is S. R. Hart, Jr. I am Vice President, Research and Development of Southern Company Services, Inc. (SCS) Birmingham, Alabama. Responsibility for the present contract with the U.S. Department of Energy (DOE) Contract Number DE-AC22-82PC50041 for operation of the Wilsonville Advanced Coal Liquefaction Research and Development Facility resides in my department in SCS.

The purpose of my testimony today is to follow-up on my testimony before this committee last year and to request funding of $6.5 million for Wilsonville in the DOE Fossil Energy Budget for FY'86 that will allow completion of the work as proposed last year. In support of this request, this testimony presents information about the objectives, accomplishments, and capabilities of Wilsonville and the rationale for the continuation of its program to completion in 1986.

It is important to consider when the work at Wilsonville should be terminated. While it is important to be able to say that we have produced more distillate per ton of coal on an integrated pilot plant scale than has any other direct liquefaction facility, it is much more important to understand how we produced more distillate so those improvements can be incorporated into the design of larger plants and used to reduce the cost of liquid fuels from coal. This is the general goal that encompasses several specific goals that we expect to achieve by the end of 1986.

Summary

The Wilsonville Advanced Coal Liquefaction Research and Development Facility has made a significant contribution to advancing coal liquefaction technology. During 1985, EPRI will provide funds to add approximately $900,000 in capital improvements to the Wilsonville pilot plant. This new equipment will provide for the testing in FY'86 of new process configurations which may further improve the process efficiency, reduce capital cost, and provide a better understanding of this complex process. Current programs which are planned through 1986 would advance this technology to technical readiness for scale-up to commercial application. The Wilsonville program for FY'86 is not expected to produce a "breakthrough" which will allow direct coal liquefaction to compete with the current crude oil price of $25 to $30 per barrel. However, it is expected to produce a data base that can be used to design a two-stage process to produce a given product slate whenever economics or national commitments permit. We currently estimate that distillate products would cost $45 to $55 per barrel (in 1984 dollars).

The major objectives can be reached by the end of 1986 and unless there is a drastic change in the nation's outlook for oil, the plans for Wilsonville will include completion of the important work currently underway followed by an orderly shutdown of the facility at the end of 1986.

Wilsonville Accomplishments and Capabilities

The Wilsonville facility consists of three major process areas. The thermal reactor unit with a design capacity of six tons of coal per day began operating with coal in 1974. The Kerr-McGee Critical Solvent Deashing unit was installed and started up in 1978. The hydrotreater unit (second stage ebullated-bed catalytic reactor) began operating in 1981. The facility also has laboratories, a data acquisition system, and a state-of-the-art wastewater treatment system.

The Edison Electric Institute (EEI) and The Southern Company system began a joint pilot plant project to study the key steps in the solvent refining of coal in March 1972. The thermal reactor unit at Wilsonville, Alabama, was completed in late 1973. EPRI assumed the responsibilities for utility industry project participation from EEI in April 1973. The U.S. Energy Research and Development Administration (ERDA), now DOE, joined EPRI as a joint sponsor of pilot plant operations in 1976. Southern Company Services, Inc. (SCS) provides overall project management at no cost to DOE and EPRI. The approximate amounts of funds provided by the participants through 1984 were ERDA-DOE, $48 million; EEI-EPRI, $32 million; and The Southern Company system, $5.7 million.

The Wilsonville facility has become a unique national asset in that it has the broadest capability of any liquefaction pilot plant in the United States, is open for the testing of proprietary technology developed by others at a meaningful scale, and produces sufficient quantities of products for small-scale combustion testing and product upgrading research. The project has consistently operated within budget.

Recent activities at the Wilsonville pilot plant have focused on the development of advanced two-stage liquefaction process technology. With two-stage liquefaction, up to 90 percent of the products can be utility fuel products: either distillates to replace No. 2 fuel oil, heavy liquids to replace No. 6 fuel oil, or solids containing no ash and about 0.2 weight percent sulfur.

Some of the more significant activities either started or completed in FY'85 include:

- Developed baseline data for comparing two-stage liquefaction behavior of subbituminous to bituminous coal. Data showed that it is possible to produce an "all distillate" product from Wyoming subbituminous coal. The distillate yield was lower and the gas yield was higher than yields from bituminous coal. Data from bituminous coal indicated that the reactor vessel is well mixed. However, data from subbituminous coal operation showed that there is a significant temperature gradient along the length of the reactor vessel. This indicates the vessel is not well mixed. The effect of reactor mixing must be quantified before the subbituminous coal data base can be completed.

- Developed baseline data for catalytically hydrotreating liquefied coal prior to deashing. Preliminary results from this test indicate that the rate of catalyst deactivation is not significantly different from the rate of deactivation experienced when feeding deashed liquefied coal to the hydrotreater. If these results are confirmed, deashing after hydrotreating will reduce the cost, due to improved process efficiency and lower capital costs.
- Completed radioactive tracer studies to characterize the thermal reactor system. These data are needed to improve the model for thermal reactor performance.

Recent experience at Wilsonville has shown that integrated two-stage liquefaction (ITSL) can convert approximately 60 weight percent of bituminous coal and 50 weight percent of subbituminous coal into clean liquid fuels. Previous work at Wilsonville demonstrated that nonintegrated two-stage liquefaction produces a significant yield of middle and heavy distillate as well as either low sulfur solid fuel or No. 6 fuel oil substitute. Some significant accomplishments from previous work at Wilsonville include:

- Demonstrated that integrated two-stage liquefaction can convert approximately 60 percent of coal to distillate fuels (1983)
- Demonstrated that nonintegrated two-stage liquefaction can produce a fuel that can directly replace No. 6 fuel oil for utility applications (1982)
- Developed a mathematical model to predict residual coal conversion in the second (catalytic) stage of two-stage liquefaction (1982-1983)
- Improved mechanical performance of pumps and valves by design changes and material selection (1974-1983)
- Proved that the SRC process can be operated in solvent balance for extended periods of time (1980-1981)
- Demonstrated operation of a state-of-the-art waste water treatment system (1979-1983)
- Provided design data for the 6000 tons per day SRC I Demonstration Plant Project (1978-1982)

Program Objectives (1984 - 1986)

There are two major reasons for continuing the Wilsonville program. These are (1) to improve the fundamental understanding of the mechanism of direct coal liquefaction and (2) to complete the development of a data base that can be used by industry to design commercial plants when economics permit. The second reason is the most important because the Wilsonville facility is the only existing pilot plant that can provide such data.

The primary program objective for advanced coal liquefaction process development is to demonstrate the production of environmentally acceptable liquid and solid fuels from coal at projected costs that would be acceptable to electric utilities and other industries. The purpose of the research is to advance the technology of multi-stage liquefaction through an ordered research program which examines the individual components of the ITSL process. This will provide the data necessary for an integrated process model, which is needed for process scale-up and design.

Previous research at Wilsonville and other coal liquefaction projects has identified those direct liquefaction processes which offer the best potential for commercialization. Development of unit process models will provide better understanding of two-stage liquefaction and will provide a basis for scale-up. Variability studies will be conducted at each of the three process units. Data from these studies will be used to develop the unit process models. The planned program would complete the modeling work by the end of 1986.

The objectives for FY'86 are consistent with the objective presented to this committee last year. Work was started in FY'84 on investigating the effect of coal rank on process performance (subbituminous coal). The results are not definitive because the first stage reactor was not well mixed. Radioactive tracer studies provided data about the mixing of the vessel that can be used for reactor modeling and for designing an improved reactor for subbituminous coal. The reactor at Wilsonville will be modified and work on subbituminous coal will be completed later in FY'85.

Work completed early in FY'85 showed promising results for close-coupling (remove ash after second reactor rather than after the first reactor) the two reactors. Later in FY'85, a new reactor (funded by EPRI) will be added at Wilsonville that will allow investigation of true close-coupled operation. The majority of the FY'86 program will be used to complete process models and to investigate close-coupled reactor operation.

Completion of the program should produce sufficient data to allow industry to scale-up the most efficient two-stage liquefaction processes to commercial size and to determine the most economical process for any given product slate. If the program is ended before the program goals have been completed, the data obtained to date will lose a significant part of their value. Currently the data are in the form of discrete points. These data cannot be used to predict what product slates can be expected from operation at conditions that were not tested. Modeling of individual process units is an essential step before the presently unrelated data can best be understood.

Funding Status

In 1984, the Standard Oil Company of Indiana (Amoco), became a cost sharing participant in the project. Amoco contributes $300,000 per year for three years directly to EPRI for support of the Wilsonville project. Funds appropriated through DOE for FY'85 will provide for 9 months of continued operation through September 1985. For FY'86, we request that $6.5 million be appropriated for Wilsonville, which will provide for operation through the end of FY'86. This is only $1.0 million more than was approved for the last nine months of FY'85. Including Amoco's support, EPRI is planning to provide up to $6.6 million in 1985 and 1986 for completion of the work outlined above. This support shows that the electric utility industry is willing to do at least its share in this cooperative program. Funding through the end of FY'86 will allow completion of the program presented last year and will provide for an orderly shutdown of the project.

DISCUSSION

Mr. **Boucher**. Thank you, Mr. Hart, and I thank all of the panel members for their testimony today.

The Energy Research and Development Tax Credits are scheduled to expire at the end of this year, and one of the items that will be on our agenda is determining whether or not they should be extended.

In light of that fact, I would be interested in hearing from the panel members first of all whether your groups receive benefits from the Energy R&D Tax Credits, whether you think they've been beneficial overall, and whether you think they should be extended. I'll ask Mr. McElwain to comment first.

Mr. **McElwain**. Our group has not had the benefit of any of the energy tax credits and I do not believe the program has been successful. I think it has, from a standpoint of somebody who's been in the operation of electric business for 30 years, to give tax credits to doctors and lawyers to make windmills, and solar, and hydro as a tax benefit under the guise of their knowing more about how to run a power facility than somebody that is in the business, is a pretty great waste of money.

Mr. **Boucher**. Thank you for that very frank expression. Mr. Fri.

Mr. **Fri**. As far as I know there's been no energy tax benefits related to the fuel cell operation. I think, as a general matter, I tend to agree with Mr. McElwain. It certainly does get out of hand. On the other hand, I think there are some areas where it is an effective tool and to go much further than that, would take more time than you and I probably both have.

Mr. **Boucher**. Dr. Solomon.

Dr. **Solomon**. There may be some trickle down effect to the fundamental R&D but I don't think it's very significant.

Mr. **Boucher**. Mr. Hart.

Mr. **Hart**. Mr. Chairman, I think I can speak much more positively. The Southern Company System has a very clear commitment to an expanded research program because we think that new technology and research are going to be the key to our success in the future. We have received tax benefits from an increased commitment to R&D. I would hope that they can be continued. In some cases where there is that marginal decision, this may be the incentive that it will take to tip the scales for further expanded research. Clearly, we have gotten benefits. We are increasing our level of commitment of our total revenues to R&D, and I hope they can be continued.

Mr. BOUCHER. Let me ask this question in a somewhat broader sense.

Suppose the energy R&D tax credits were expanded to provide incentives, not just for renewables which is apparently what they're limited to today, but to the kinds of work that you're doing. Would you see that as a positive approach as opposed to direct Government funding of your research projects?

Mr. MCELWAIN. From the standpoint of MHD, I think it's at a point where the program should continue through proof of concept by the Federal Government. I don't think that, at least from the standpoint of a good many utilities in the United States today, a good many of them could take advantage of the tax benefits anyway because of their tax position. Certainly that's the way of the former company that I headed.

Mr. BOUCHER. Let me ask if anyone else would like to comment on that question.

Mr. HART. I think it would depend on how the tax credits would be structured. Please be aware that much of our research is dedicated to ways of making existing facilities more productive or more environmentally acceptable in their operations, and therefore the energy credits should not be just limited to new facilities if they're expected to provide substantial R&D support.

Mr. BOUCHER. Mr. McElwain.

Mr. MCELWAIN. I just wanted to correct. Apparently I misstated myself that the proposal that we have before DOE under their clean coal concept—one of my colleagues advises me that I used the term oil-fired retrofit—it is a coal-fired retrofit to go along with the CDIF and the Tennessee project to get this concept retrofitted and on line.

Mr. BOUCHER. Mr. McElwain, have any utilities other than Montana Power expressed an interest in developing the MHD process?

Mr. MCELWAIN. They have. There's an organization involving 22 other utilities that have worked closely with our group and the group that I have set forth. Here we have some commitments from some of those people by way of letter at the time, but time did not permit me to get them in my testimony.

Mr. BOUCHER. What amount of development do you think will be necessary before private utilities are willing to commit their own funds to the MHD program?

Mr. MCELWAIN. I think that we need to put together what has been done at the CDIF in Butte, and what has been done in Tennessee, and at Argonne into a working, pilot model that shows that all of the things, when they come together, work. I think I'm very encouraged that there's no reason why that shouldn't put itself together into a pilot project and that's what's required for the 5-year multiyear program that I suggested would go jointly along with what we're proposing in the way of a retrofit.

Mr. BOUCHER. Can you tell me about how many years it would be assuming that you receive appropriate funding this year, before we will see private dollars invested in MHD?

Mr. MCELWAIN. The Montana Power Co. made a commitment to donate a 60 megawatt facility to the retrofit process which has been estimated would save overall some $150 million in ground-up new facility.

Mr. BOUCHER. When is that donation scheduled to occur?

Mr. MCELWAIN. It's scheduled to occur within the next—well the commitment's been made—it's scheduled to occur when and if the clean coal proposal that we have before DOE at the present time is accepted, and it's going along at the same time as the proof of concept dollars would make everything on go systems at CDIF.

Mr. BOUCHER. I would suggest to you that donation of a facility such as that, while perhaps valuable to the development of the program, still is not quite the same as the donation of dollars. I wonder at what point in time we can expect to see utilities, including Montana Power, actually contributing dollars to the development of MHD?

Mr. MCELWAIN. I think that's being done to a limited extent at the present time. Montana Power Co. funded originally MERDI, which is the forerunner of the CDIF at the present time, and there have been commitments by three organizations to the funding of the MHD Development Corp. on a small scale to keep it going until we see where we are to the extent of $75,000 to $100,000 at the present time.

I believe that proof of concept going along, you will see if there is a commitment on the part of the Government to move forward with this, you will see private money willing to expend itself. I'd say if there was a commitment on the Government to a 5-year program and there would be commitment on the part of these companies to go ahead with the engineering work, at the end of the 5- or 6-year program of the Government they could be able to move forward into the hardware part of the work.

Mr. BOUCHER. So you're saying at the end of 5 years, we might expect some contribution of private dollars?

Mr. MCELWAIN. I think there would be contribution of some kind of private dollars during the 5-year period of going forward with the program in tandem with the proof-of-concept.

Mr. BOUCHER. I think it might be helpful to the committee if you could submit for us an itemization of the private dollars that are being committed today.

Mr. MCELWAIN. I would be happy to do so although it may not seem that $150 million contribution of a plant is very much, but it's saving the Government those kind of dollars or the concept those kind of dollars—just as the engineering work some of these other people are moving forward with a retrofit and saving dollars, too. Whether it's in kind activities or whether it's out-of-pocket dollars, I think it moves the process forward just as much.

Mr. BOUCHER. Let me ask if you would submit this; a statement of either in kind or direct dollar contributions that are being made today and any anticipated schedule that you can presently make of similar contributions over the next 5 years and then perhaps at the end of the 5-year government program. If you could submit that, I think it would be very helpful.

Mr. MCELWAIN. We will do what we can for you. There are letters of intent of these organizations that I've named attached to my prepared testimony.

Mr. BOUCHER. Mr. Fri, I'm going to ask you a similar question with respect to fuel cells. At what point would you anticipate private investment being made in their development?

Mr. FRI. Private investment in the electric application of fuel cells began in the early 1970's. Since that time, approximately two-thirds of the total development cost has been private sector money, contributed both by utilities by the manufacturers, and by the utilities through the Electric Power Research Institute. As we move into the stage of commercialization, we're looking at something like a similar amount of money which will be placed at risk by the manufacturers in order to go into the business of making fuel cells, which will start essentially immediately, and will ultimately be refunded to the manufacturers through sales of the first 20 or so fuel cell units. This has been a largely private program for a very long time.

Mr. BOUCHER. Thank you very much. Dr. Solomon, I was very interested in your testimony concerning basic coal research and I wonder if you could make some recommendations for us. Given the limited resources with which we're working today, can you identify just two or three basic coal research areas that you think are most important and should receive our highest priority for Government funding?

Dr. SOLOMON. I think that the most appropriate goal is to provide a foundation of predictive capability so that what we need to do is measurements of the basic chemistry, the basic reaction rates, the basic physical processes that go on with coal and other alternative fossil fuels. A lot of these processes are common to all of the commercial utilization processes, combustion liquefaction gasification. Things such as coal pyrolysis, heat transfers, and things of that sort which are all common and our study of the structure and the chemistry of those initial reactions would be providing a foundation for predicting on all of these types of processes. I think the focus should be the research that would be both experimental and modeling to build predictive capability.

Mr. BOUCHER. I've recently been made aware of an advance in the use of coal to power diesel engines, which I think is very promising. I wonder if you are aware of this as well. My understanding of the technology is really a layman's understanding but apparently what is happening, is that coal is being heated to the point that the volatiles are driven off, they are then condensed into a liquid, and that liquid is then mixed with the char and that product is then being used in a liquid form in the place of diesel oil in diesel engines. Apparently it works. Are you familiar with that?

Dr. SOLOMON. I am embarrassed to say I'm not. I made a note when you mentioned it this morning and I'm going to find out about it.

Mr. BOUCHER. I was very impressed with your testimony and I would be interested in receiving your comments on the advisability of further research in that particular area, and if you see items that need refinement in where you think the Government can exercise a proper role in advancing research, I would appreciate having the benefit of your recommendations.

Mr. Hart, we've been advised that there recently has been an installation of a 40-kilowatt fuel cell at the University of Alabama. I would appreciate knowing what the experience with the installation of that facility to date has been.

Mr. HART. I can report that the experience has been very good from the time of delivery until initial operation of the fuel cell. It was about 2 weeks because of the modular construction of this 40-kilowatt unit. The unit has operated and reached by the end of 1984 about 1,800 hours of operation from October 15, so we had a high level of online availability. The uniqueness of this particular installation had to do with operating the 40-kilowatt fuel cell off of coal bed methane gas, which is a fuel source that up to now has not been utilized and is reported to be very abundant in our area in Alabama. To date, there have been problems by the University of Alabama under a separate research contract in producing sufficient quantities to supply the fuel cell entirely with coal bed methane gas. We do expect to go to operation of coal bed methane gas within the next 2 weeks. We will continue to monitor the operation. Overall, I can say that it's been very successful. We have supplied all of the hot water heating requirements for a large student recreational facility and about 35 percent of the electric energy requirements during this period of time.

Mr. BOUCHER. Thank you, sir. Mr. Traficant.

Mr. TRAFICANT. Thank you, Mr. Chairman. Some of the comments in the earlier statement of Mr. McElwain—I agree that coal is our greatest energy resource. In taking that, my first question would be for Dr. Solomon. If our funds were limited to the point where only one basic research program would exist relative to coal, in your position, what do you recommend that process should be?

Dr. SOLOMON. The predictive capability is not going to be—again, I think the focus is developing this predictive capability, whether it be for combustion or gasification or liquefaction, the general science of what is going on with the coal; I think that ought to be the focus. With that as the goal, you can identify the weak links and there are 10 or so. If you just work on one, it's not going to do any good to the overall predictive capability.

Mr. TRAFICANT. As we talk about these different areas, we start looking at cost versus benefit factors. In considering these cost versus benefit factors, what one area seems to be the most promising if you were to look at it through research and development as far as the future for coal? What recommendations might you have in your position along those lines?

Dr. SOLOMON. Those are very difficult questions. I think the most immediate use of coal is coal combustion. We are burning more coal than anything else. The most immediate extension of that is probably expanded coal combustion, something like cold water slurries. Now you get into the question of isn't that far enough along so that the private sector is going to pick that up. I really don't want to answer the question about process. What I would like to say is that our main responsibility of the Government is to provide a very sound foundation for coal science. To be able to design that process and choose that process, that's the foundation which is now missing. We really don't have a sound foundation. All of these things about well, Ohio coal is different from Pennsylvania coal, and we can't scale up; all of those have to do with a lack of understanding as to what the differences are. Those fundamental things about the chemical we're dealing with is the thing that is missing. That kind of research program is not expensive—not expensive in today's budget—in today's budget, everything is expensive.

Mr. **Traficant**. In another vein relative to research, how much is the academic community involved in the research relative to coal versus the Government agencies and their contractors.

Dr. **Solomon**. I'm sorry. I don't understand the question.

Mr. **Traficant**. How much research and development is being done at the university level?

Dr. **Solomon**. That would all be funded from the Government. I don't have the total number of dollars at the present time. I could try to get that.

[The information follows:]

American Chemical Society

DEPARTMENT OF GOVERNMENT RELATIONS
AND SCIENCE POLICY

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4477

March 20, 1985

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development
and Applications
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Congressman Fuqua:

The American Chemical Society appreciated the opportunity to testify before your Subcommittee. Dr. Peter R. Solomon, Chairman of the ACS Fuel Chemistry Division, presented our testimony. Following his presentation, he was asked several questions to which he has personally responded with his views and those of his Division, when possible.

As requested, the ACS Department of Government Relations and Science Policy is providing the enclosed information in response to the Subcommittee's question about amounts of federal funding supporting coal research at universities.

Please feel free to contact us if the Society can be of further assistance to the Subcommittee.

Sincerely yours,

Kathleen A. Ream

Kathleen A. Ream
Head

Enclosure

cc: Dr. P. R. Solomon

Coal Research Supported By DOE at Universities [a]

(FY 1984, dollars in millions)

Program	Univ. Support Plus Fed. Labs and ETC's	Univ. Support Minus Fed. Labs and ETC's
Fossil Energy	\$25.53[b]	\$19.63
Chemical Sciences	\$ 0.69[c]	\$ 0.37
TOTAL	\$26.22[b,c]	\$20.00

[a] Source: The DOE Office of Fossil Energy and the Division of Chemical Sciences.

[b] Includes University of North Dakota Energy Research Center, formerly a DOE Energy Technology Center (ETC).

[c] Includes Ames Laboratory at Iowa State University and Lawrence Berkeley Laboratory at the University of California.

Mr. **Traficant**. Do you believe there should be more of an involvement of the university community into research programs through Government contracts of this sort to further energy research and development capability?

Dr. **Solomon**. There are two reasons for involving the university. One is to provide research projects which will educate our future scientists in alternative fossil fuels and I think that is a legitimate reason to fund universities. Other than that reason, I think that the major criteria for what sort of an institution gets funded is the quality of their proposals, their ideas, their facilities, and their people. The university ought be treated specially because of its education function, but then ought to compete with the other organizations in terms of the quality of the ideas they put forth.

Mr. **Traficant**. I really appreciate the comments made. Our concern in the State of Ohio happens to be coal and the utilization of that coal is of prime importance if we're going to take the energy dependence we have on Third World nations; that's for a fact. I'd like to know, in line of what the chairman asked about the tax credit situation, if you would also perhaps enclose your own position, just briefly, as to how we might be able to get the private sector more involved into research and development along the lines of energy and what you'd see from your position might be relevant so as to attract those types of interests.

Mr. McElwain, what do you think would be necessary to involve outside money other than traditional Government funds to further R&D programs?

Mr. **McElwain**. I think you have a considerable amount of involvement in coal research in areas other than MHD. I happen to be one of those people who are very high on MHD because of its great possibility of payout. It has a possibility of solving our acid rain problems and at the same time, upgrading the utilization of the coal itself from 30 percent up to 45 or 50 percent efficiency. That not only helps out the conservation of our coal, but it does a great deal to transportation and making it more economical to utilize coal over more of the country. I think it has the greatest potential for the highest payout. In answer to other research efforts, we have several going on at Montana Tech in Butte and several at Montana State University. The State's been participating in some of this effort to a considerable extent and I believe is considering at the present time a portion of their coal severance tax being put to use as coal research moneys.

Mr. TRAFICANT. I would ask the same question of Mr. Fri.

Mr. FRI. That question could have a very long answer. Let me give you one brief answer. I think to attract more private money into the energy research and development area, one thing that would be very helpful would be for the Department of Energy to understand that some followthrough in support of development effort, to maintain the technology base undergirding a specific new process, is crucially important during the commercialization process. While it's proper policy to take the stand that the bulk of government funds should go for early high risk potentially high payoff research and development, I think it is a poor way to save money not to spend that extra backup followthrough to see to it that the technologies that are winners make it all the way through to commercialization. I think the Congress has been pretty good about seeing that. I think the hearings this committee had last year reflected that, but it's a false economy not to have that followthrough.

Mr. TRAFICANT. You more or less see it as government sees a problem and throws money at it and when the problem seems to abate itself a little bit, they pull back and withhold from long-term commitments to really handling it.

Mr. FRI. Take for example the Westinghouse program in fuel cells which was blocked out with some funding of $100 million or so, which was shared by utilities, by the Federal Government, and by Westinghouse Corp. The Government, to be sure, was putting up the bulk of the money up front, but the way the program was put together, the basic technology support from the Government did not just evaporate at the end of a couple of years. It got smaller and more tightly focused on the things that were still under research. The private money came in more and more strongly where there were real commercial problems to deal with, but it was a cooperative program where the Government role phased out and the private sector money phased in over a planned period of time. It worked pretty well. Sustaining that kind of commitment is something I think the Federal Government ought to do. It doesn't make any sense to spend the first $35 million of your $40 million share and say we've come far enough.

Mr. MCELWAIN. May I make one additional comment? Over 60 percent of the coal reserves of the United States are located on Federal lands. To the extent that the Federal Government makes the utilization of coal and clean coal something that is acceptable in our energy picture, they're going to benefit monetarily from the royalties of that coal. It's a very important concept that has nothing to do with bailing anybody out but it has to do with being a proposition that makes sense for the Federal Government to get in there and get a way to use the coal.

Mr. **Traficant**. No question. You could reverse the analogy and you could say that if at 60 percent coal on Federal land, there should perhaps be a posture of government that 40 percent of the funding for R&D for energy purposes should come from the private sector. That wouldn't rest too well with you there.

Moving down the line, Dr. Solomon, your answer to the question.

Dr. **Solomon**. We're getting way out of my area of expertise but it seems to me that what you're trying to do is change the market picture. People are not putting money into these things because they can't sell the power. If you tax the oil, especially the imported oil, and turn around and take that money and subsidize the alternative technologies, I think that you would change that market situation. Notwithstanding that encouragement of increased use of coal, the long range R&D I think is permanently the Federal Government's responsibility. I think that is something that is just too far off. We're talking about things that are more than 5 years away and industrial organizations just won't support things that are more than 5 years away.

Mr. **Traficant**. Mr. Hart.

Mr. **Hart**. I don't want to hide under the umbrella of our regulatory process that gas and electric utilities are facing, but it's a fact of life and this limits the risk that we can take in bringing some of the new technologies to commercialization. I think there's a very key role for the Government in participating and in an assured manner so that we aren't left with uncertainties from year to year on large projects. There are a number of examples that we could cite now where the team approach has proven to be successful. I think somehow we've got to be assured that Government participation is going to allow us to bring these new technologies to the point of commercialization because as long as there is some element of risk out there and given options where you have the conventional technology versus the new technology and there's not sufficient incentive between the two, we're going to go with the established technology simply because the penalties of the failure are so severe under the regulatory process. I think this difference can often make a major contribution in advancing new technologies under those circumstances.

Mr. **Traficant**. Thank you. Thank you, Mr. Chairman.

Mr. **Boucher**. Mr. Cobey.

Mr. **Cobey**. No questions.

Mr. **Boucher**. I would like to thank this panel for its very useful testimony today and, with the conclusion of that panel, our hearing is concluded.

[Whereupon, at 1:10 p.m., the subcommittee recessed to reconvene at the call of the Chair.]

APPENDIX I

Additional Statements for the Record

ENERGY RESEARCH CORPORATION

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A SUBSIDIARY OF
ST.JOE
MINERALS CORPORATION

WL 85-11

March 6, 1985

Honorable Don Fuqua, Chairman
Energy Development and Applications Subcommittee
House Science and Technology Committee
B-374 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

As an unfortunate consequence to the Subcommittee's rapidly changing hearings schedule, the ERC testimony was not presented at the session devoted to the DOE-Fossil Energy Budget today. This is particularly crucial to our continued success in the research underway in molten carbonate-based fuel cells employing internal reforming, currently missing in the Administration's Budget Request.

I am enclosing the testimony I planned to present and ask that it be accepted and distributed to the Subcommittee. I have also included statements on the DOE-sponsored nickel-cadmium electric vehicle battery research, associated with the DOE-Conservation Division program. This program, begun in FY 1985, will provide an EV battery capable of meeting most, if not all, the near-term mission goals for this application.

I welcome the Subcommittee's questions and desire for more information on these programs. I have had several discussions with Mr. Harvey, EDA Staff Director and trust that with continuing dialogue, your Subcommittee can assess the worthiness of these areas for sustained support.

Very truly yours,

Donald R. Glenn
Director of Program Development
& Washington Operations

enc.

cc: W.T. Harvey, EDA Staff Director (w testimony copies)

ENERGY RESEARCH CORPORATION

Statement of Donald R. Glenn
Director of Program Development
Energy Research Corporation

U.S. HOUSE OF REPRESENTATIVES
Committee on Science and Technology
Don Fuqua, Chairman
Subcommittee on Energy Development and Applications
Hearings on Fiscal Year 1986 Authorization
for
The Department of Energy's Fossil Energy R&D Program
and Transportation Energy Conservation

March 11, 1985

Testimony

I am Donald R. Glenn, Director of Program Development for the Energy Research Corporation (ERC), a subsidiary of St. Joe Minerals Corporation, a Fluor Company. I appreciate this opportunity to present this statement to your Subcommittee covering several important cost-shared research programs sponsored in part by the Department of Energy (DOE) and falling under the Subcommittee's jurisdiction, in consideration of the FY 1986 Budget.

ERC, in celebrating its 15th anniversary this year, has maintained our founding objective, to engage in all aspects of electrochemical energy conversion and storage functions, from exploratory research through marketing of finished products. In pursuit of this charter, ERC has grown to a staff of over 150, with approximately 40% possessing directly relevant technical degrees. ERC is among the top two or three largest U.S. companies developing advanced batteries and fuel cell technologies, and may be the largest firm dedicated solely to producing electrochemical power components and systems. ERC is located in Danbury, Connecticut.

We maintain a continuing concern for our Nation's energy security, particularly with respect to petroleum supplies. ERC believes that demands for power will favor technologies able to supply electricity at smaller scales than associated with nuclear and coal-fired base-load utility powerplants. This reasoning results from a realistic perspective of new powerplant orders, greater dispersement of our population to suburban and rural settings, and a shift in power demands from heavy primary industrial plants to smaller, less energy-intensive manufacturing operations. These trends have utility decision-makers revising new capacity addition strategies to compensate for troublesome and lengthy nuclear licensing and construction lead-times, and environmental controversies. A recent Worldwatch Institute report, "Electricity's Future: The Shifts to Efficiency and Small-Scale Power," by Christopher Flavin, clearly defines this prognosis. ERC expects that, at least for the remainder of this century, the demands for powerplants in the 100 kW to 200 MW range, will grow dramatically to serve industrial, residential and commercial consumers. Most importantly, this demand will also insist on reliable power at higher energy efficiency, with reasonable economic pay back on capital. Most knowledgeable energy forecasts predict a return to higher energy prices and disappearance of the "energy bubble" shortly, as the world economic recovery absorbs the present energy excesses, assuming no premature disruptions. For these reasons, ERC has intensified efforts to bring our best technologies to maturity, and to the Subcommittee's attention.

I am pleased to report to you on some significant progress in our on-going programs in phosphoric acid fuel cells and the molten carbonate-based Direct Fuel Cell (DFC). In addition, two new DOE projects were initiated in our Battery Division, involving our nickel-cadmium and zinc-bromine electrochemistries as applied to electric vehicles and utility load leveling. Each of these activities contributes to reductions in petroleum dependency, responsiveness to rapid load changes at much higher total energy efficiencies than current hardware, and at very competitive costs helping to keep energy prices in check.

By way of example, our molten carbonate based-Direct Fuel Cell can produce electricity at a cost of about 6¢/kWhr based on the current price of natural gas (at $4.00/mmBtu). This compares with about 12¢/kWhr for new nuclear plants.

The efficiency of the natural gas fueled plants is relatively independent of size and may provide additional cost benefits since these plants can be sited near the user where waste heat credits could provide additional energy savings. The siting flexibility comes about because the fuel cell is environmentally benign, silent and compact. A 2 MW Direct Fuel Cell powerplant requires only 2/3 acre! A coal-fueled MCFC using ERC Direct Fuel Cell technology can produce electricity from coal for 5.5¢/kWhr, using a coal price of 50 $/ton.

Complimenting the DOE funds, all these projects have financial encouragement from the private sector, including ERC discretionary funds, additional evidence of these programs' importance, priority and high expectations.

I would now like to briefly report some of the technical successes we have achieved in the past year on DOE and related projects.

Phosphoric Acid Fuel Cells (PAFC)

ERC has several important programs that embrace PAFC technologies. These include research in processing incoming fuels for fuel cells, development, manufacture and testing of portable, stand-alone small power systems (to about 10 kW), and perfecting electric utility/industrial-sized full stacks (at 100 kW/stack), the heart of a fuel cell power system. Major accomplishments this year have included delivery and subsequent successful operation of two 3 kW fully automatic PAFC units to the Army/Ft. Belvoir, and a 20 kW stack and reformer to DOE/Los Alamos. The 3 kW units are state-of-the-art equipment containing a fully-integrated microprocessor controller capable of remotely activated self-starting, shut-down and limited troubleshooting/fault isolation, a major milestone towards the mass-production of a consumer-oriented product. These powerplants meet or exceed contract requirements for efficiency and start-up time and represent the first successful demonstration of militarized fuel cell units for the military. Another significant advance in 1984 was to incorporate a water recovery subsystem, using formerly-rejected water vapor-laden thermal energy from the fuel cell stack. This, when fully implemented, will allow "neat" methanol, a pure fuel, to be the primary fuel source in place of the now specified "premix" methanol, a 52% methanol/48% water mixture. This change alone will extend the plant operating duration between refueling to about twice that now presently attained. This refinement also improves the operating efficiencies through reductions in rejected thermal energy and reuse of preheated water/steam in the methanol reforming function. In addition to processing methanol (and natural gas), ERC is researching other fuel processing methods to offer greater flexibility in fuel selection thus extending fuel cell power availability to a broader market.

ERC provides technical support to the Westinghouse Electric Corporation in their utility-directed program. We have built and operated up to 10 kW pressurized stacks that are between 5-10% of meeting Westinghouse powerplant design goals. Westinghouse, with ERC support, will build the full-scale 100 kW stacks. ERC has defined and successfully demonstrated the needed improvements to reach the design goal (690 MV @ 267 amp/ft²) under the DOE/Westinghouse utility-directed program. Moreover, this performance is fully competitive with that achieved by other major fuel cell organizations at a fraction of the other program investment costs.

Molten Carbonate Fuel Cells (MCFC)

This fuel cell technology is the most efficient power generator conceived and should be available to our society shortly. Capable of serving markets needing 100 kW to hundreds of megawatts, the MCFC produces essentially no pollutants and reduces carbon dioxide emissions approximately 50% over conventional coal-steam powerplants. EPA reports that in 1980 stationary power systems produced 21.9 million tons of SO_2 and 13.3 million tons of NO_2. Fuel cell power, linked to modern coal gasification processes, can virtually eliminate these streams and dramatically improve the "acid rain" impacts associated with coal-fired systems (Figure 1).

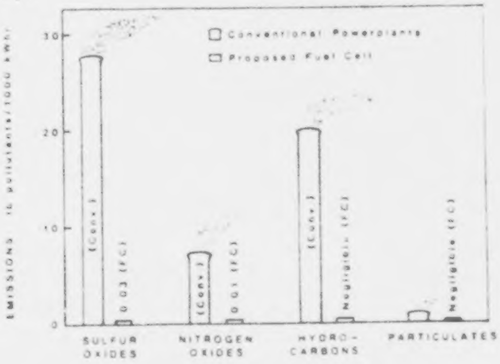

FIGURE 1
COMPARISON OF POLLUTANT EMISSIONS
FROM COAL-FIRED CONVENTIONAL
AND FUEL-CELL POWERPLANTS

D2163

We are eager to make this claim a reality and applaud the creation of the Clean Coal Technology Program sponsored in part by members of this subcommittee as a mechanism to catalyze this potential. A new Congressional Research Service report, (85-523 SPR), "Fuel Cells for Electric Power Production: Future Potential, Federal Role and Policy Options", just published on January 17, 1985 is an excellent treatise on the technical and policy issues affecting these fuel cells. I am also pleased to note the report's recognition of the ERC Direct Fuel Cell potentials from among the current candidates in development.

At ERC, we have adopted several important design and technology philosophies very compatible with the Congress' definition of the appropriate Federal role (in this R&D), that of realizing a demonstrable working unit as soon as possible and affect a transfer then of the financial burdens to the private sector. A most important direction, was to establish ambient pressure operation as our baseline, with pressurized capability as an option that can be included later, if desirable. This decision simplifies the technical hurdles to concentrating on the thermally-imposed issues of cycling and sustained operation on the cell components. ERC has shown that very satisfactory performance and high efficiency are attainable at affordable projected total costs of approximately 900-1000 $/kW. A second direction, a clear ERC distinction in technology advancement, was to include the fuel processing function within the cell stack itself. ERC's Direct Fuel Cell (DFC) not only reforms methane, natural gas or methanol directly, internally, it has lower temperature gradients due to the synergism between the endothermic (heat demanding) reformation reaction, and the excess heat generated by the other cell chemical reactions. The resulting hardware embodiment is much simpler, requires less space and is more reliable as peripheral support systems hardware are minimized. Because of the Direct Fuel Cell's ability to use methane, it is possible to develop more efficient coal gasifier/fuel cell combinations. The cell's feed gas mix can contain a mixed stream of hydrogen, carbon monoxide and methane. Thus lower amounts of oxygen are needed by the gasifier and no reforming of the methane outside the fuel cell is necessary. This important gasifier/fuel cell option has not yet been fully explored let alone optimized.

This past year, ERC accomplishments include:

- further endurance testing of DFC test cells to over 7000 hours with a electrochemical performance decay rate of 5 mV/1000 hours, about the same as the present, more fully developed PAFC systems.

- a breakthrough in solving the dissolution problem of the nickel-based cathode with substantially improved corrosion resistance, the first organization able to report this very significant step forward.

- dramatic reduction in the anode creep rate, a critical element in extending the life of multicell stacks.

- continued improvement in molten salt electrolyte management.

- improvement in the DFC anode compartment design to a flow-by configuration that lowers the cell internal resistance with no sacrifice in reforming activity .

- development of large size, dimensionally stable fuel electrode materials. All DFC components have been upscaled to 1 ft^2 or larger and are ready for the next step, stack assembly and test.

Largely because of the self-contained, highly integrated design, ERC projects that a 50-100 kW sized DFC on-site integrated energy system will be 40% less costly, occupy half the space (footprint) and be 50% more efficient than the current PAFC 40 kW units! It will be fueled by coal-gas, natural gas, methane, methanol, or any combination of these energy sources. Assuming continuation at the present rate of progress, and commensurate funding, this unit can be demonstrated in late 1988.

As a further sign of our confidence that the DFC prototype full stack will be ready in 1988, ERC has submitted a proposal to site and demonstrate a coal-gas fueled 5 MW DFC powerplant, in response to the Congressionally-mandated DOE solicitation for projects employing emerging clean coal technologies. It is ERC's intent to have this system in place and on-line in the 1991-1993 period; Pacific Gas and Electric Company, San Francisco is our utility partner in this project. Most importantly, this aggressive position assumes that the ERC 3-year stack development program funding from DOE and EPRI is sustained to continue scale-up to a full-sized cell and stack configuration already underway. Our EPRI-funded projects have also developed improved system configurations using commercially available balance-of-plant components in addition to first stack designs. Averaging approximately 25%, the private sector contribution is an early indication of confidence and interest in the DFC.

I am sorry to see the Administration's proposed FY 1986 budget for the MCFC program falling short of the needed levels once again. At ERC, much has been accomplished with the modest funds expended to date. While DOE has been required to prune budgets as part of the deficit-cutting goals, the DFC is at a crossroad, innocently ill-timed to this broad issue. In our testimony before this subcommittee last year, I presented a 3-year program plan with a request for DOE support totalling $12.5 million to reach the full stack test milestone by 1988 (FY 1987). Your continued support in FY 1986 and 1987 is crucial if we are to see this marvelous advance materialize. At that point, the nation will have a 60% efficient electric generator that is silent, with very low pollutant emissions and a projected fuel cell cost of 700 $/kW! With this achievement, I am confident that the private sector will largely assume the additional support to commercialize the system in the 1990's. ERC continues to try to attract other financial interests, however, completion of the basic building block, a full-scale stack, is a critical condition for any substantive support apart from government and other research funding agencies. Consistent with my statement of the total program need in last year's testimony. I ask the Subcommittee to consider a $4 million level in FY 86 to continue the direct fuel cell stack development efforts.

This is a very special project. We are proposing here not only the most efficient fossil fuel plant ever built, but also the most efficient that can be built based on the laws of thermodynamics. We almost have it. The nation (and the world) will realize significant benefits from its widespread use.

Nickel-Cadmium EV Batteries

ERC has been engaged in the development of advanced nickel alkaline batteries for fifteen years. In 1980, ERC was contracted by the Navy, to perfect a large nickel-cadmium battery for submarine use. It is intended to replace lead acid cells and provide twice the power stored for the same weight, and in 50% of the volume. Stemming from a unique patented approach to producing electrodes through a nonsintered, ambient temperature manufacturing process, we have completed the fabrication of the full scale (and world's largest) cell at 8000 ampere-hours this past year. This cell is exceeding all contractual requirements, based on recent characterization tests and earlier sub-scale cell designs. These cells are workhorses able to withstand very high discharge rates and rapid charges over a comparable life to lead acid batteries (>1000 cycles). The key features of this ERC technology are:

- twice the stored energy capability than lead acid batteries on a weight basis.
- 50% increase in energy density on a volume basis.
- rapid recharge rate.

With this success, it was apparent that other markets might benefit from this work. One spinoff has been a miner's cap lamp battery. At 2.4 lbs., it is almost half the weight of the lead-acid version it is to replace, a major improvement when you consider that the battery is worn on a belt for a full shift (8-10 hours)!

These characteristics have led ERC to propose Ni-Cds for electric vehicle (EV) applications. Though the current cell design is not optimized for EV use, ERC installed a battery set in one of our Executive cars and has been running this vehicle, gathering data and confidence, for almost a year in everyday commuting situations.

The Ni-Cd battery is not an ultimate EV battery, however, it appears to be the best nearer term option to lead in the introduction and transition to EV's. It's physical appearance and handling characteristics are much like present lead-acid cells, an advantage for market acceptance. It has a modest salvage value to assure a recycling procedure identical to present batteries, and conservation of a somewhat limited resource (cadmium). ERC is embarking on a cost-shared three-year program with DOE to optimize this technology for vehicle use. The effort will produce a battery and electrical "fuel gage" compatible with consumer expectations for a low (or no) maintenance battery, that will extend EV ranges to about 125 miles, at competitive costs on a life cycle basis. The Ni-Cd represents a "best" opportunity for providing a viable battery that will work and be capable of yet an additional 25-40% increase in performance through further technical refinements.

The program requires \$2.5 million from DOE with private sector contributions expected to be approximately 40%. In FY 1985, Congress appropriated \$0.5 million for the first year's activities. To complete this effort, I urge the Subcommittee (and Congress) to provide \$1.0 million in each of the next two fiscal years (1986 and 1987). The long-standing Congressional concern for an electric vehicle capable of competing with gasoline-fueled units will finally be within reach. ERC analysis shows that this battery can compete in European markets now, where fuel prices are about twice that found in the U.S.

Summarizing, ERC is at the forefront in several emerging energy technologies for advanced batteries and fuel cells. The particular programs highlighted in my testimony, the Direct Fuel Cell and Nickel-Cadmium batteries for Electric Vehicles, can dramatically reduce demands for petroleum fuels in favor of added coal use while providing higher efficiencies and lower costs than alternative solutions. These programs are well-along towards completion of their respective R&D requirements. They enjoy substantial private sector interest and funding support, a primary requisite for Federal encouragements. That is, commercial interests are actively contributing their share and mechanisms for market introduction and acceptance is in place early in the R&D cycle. This does not mean the R&D job is done yet. Each of the programs I described have some finite work remaining that, without continued and adequate Federal support, will struggle at best, and more likely disappear. These projects have a history of positive and measurable successes, with potentials to dramatically change their respective markets and the nation's energy posture.

Thank you for this opportunity to present this statement.

Office of the President

IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312/567-4001

March 14, 1985

The Honorable Don Fuqua
Chairman, Committee on Science and Technology
The House of Representatives
Rayburn Building, Room 2269
Washington, D.C. 20515

Dear Mr. Fuqua:

While the House Committee on Science and Technology is reviewing the budget request by the U.S. Department of Energy (DOE), I would like to raise several points for your consideration. My particular concern is the Enhanced Oil Recovery and Advanced Process Technology programs. Our economy is based on petroleum, and our need for quality liquid fuels will continue well into the next century. For this we depend on domestic crude oil production or imports. The short-term supply/demand situation is only part of the problem, with reserves being the long term and ultimate factor of importance.

Conservation is an important factor and has contributed significantly to reducing our oil imports. However, the shock of previous gasoline shortages is subsiding and crude oil prices are decreasing. These factors will result in a decrease in the public's effort in conservation. This is evident by recent increased sales of larger, less economical motor vehicles and increased recreational travel. Also, the move towards small, fuel economy cars was a one-time savings that cannot again be duplicated.

Crude oil consumption, imports, and price are all down from previous years, but domestic demand and imports are beginning to rise again. U.S. oil production has not held steady despite increases in drilling activity; U.S. crude oil reserves are declining alarmingly.

Some salient facts concerning the last 10 years should be mentioned. Crude oil production in the lower 48 states has declined more than 25 percent, even though the real price for crude oil quadrupled, permitting additional production from marginal wells. The number of wildcat wells has doubled, but less than one-fourth of domestic oil production is being replaced by new discoveries. These reserve additions required drilling significantly more higher-cost wells, which have found smaller and smaller fields. Also, as much heavy crude as the refiners will accept is being produced.

As conventional domestic reserves become more scarce and economically marginal, development of new technologies and "frontier" regions are the only domestic options for replacing reserves. Some studies have shown that the cost of replacing crude oil reserves by drilling could rise to $50 a barrel by the year 2000. Discouraging results from the $140 million Mukluk well in Alaska and from exploratory wells in the Atlantic offshore could argue that replacement costs will be even higher.

Synthetic liquid fuel will have an equally high price tag and cannot be easily processed and utilized. Even the heavier natural crudes are causing refining problems when added only in small quantities to conventional light petroleum feedstocks, and the resultant fuel quality cannot be easily predicted.

The domestic petroleum industry is showing signs of following the steel, consumer electronics, and automobile industries toward reliance on foreign supplies. Increased imports will reduce domestic employment, productivity and economic activity and increase the balance of payment deficits. Federal and state tax bases are already being reduced.

A significant contribution to offset the domestic production decline could be made by improving the recovery from known petroleum resources. The total U.S. original oil-in-place in reservoirs discovered to date is about 480 billion barrels (BB). One hundred thirty BB have been produced, and about 30 BB more will be produced in the future. The difference, 320 BB, cannot be economically produced by conventional recovery technology. For every one percent of this residual target oil that could be recovered (by any method) one year's production at current rates, could be salvaged. The just-published report from the National Petroleum Council to the DOE concludes that over 30 BB of oil could be recovered with advanced enhanced oil recovery technology at rates of between one and two million barrels per day from 1990 to beyond 2010.

This oil that remains after primary and secondary recovery is trapped by capillarity, remains in zones of the reservoirs that could not be swept by injected fluids, or is too viscous to flow. Neither the properties nor the location of this oil is adequately understood--nor are the technologies for reaching, displacing, mobilizing, or producing it. Research is desperately needed to improve methods for characterizing the reservoirs, improving present enhanced recovery techniques, and developing of new recovery technologies.

Compounding the problems is that more and more heavy crude oil resources will be needed to supplement our light oil production. There is a scarcity of data on the fundamental chemistry of these oils that is needed to design efficient techniques for refining and upgrading to provide maximum utilization of the products.

Industry does not have the incentive to perform the necessary long-term basic research. Even under the windfall profits tax, industry is motivated toward the "big discovery" in exploration efforts. There is no doubt that gradual improvements are being made in enhanced recovery technologies, but at the present rate of technology development, most oil fields will be abandoned prior to any technological breakthrough. And any potential incremental oil recovery will be lost forever.

If these known residual oil resources are not exploited, new supply technologies will enter the market as replacement costs escalate, and an unreasonable cost of liquid petroleum will occur much earlier than optimum economics would indicate. Continued funding of petroleum R&D at the modest levels requested by DOE will help advance the technology base and make advanced recovery processes available especially to smaller companies and independent operators.

For the above reasons, I would ask that this committee not recommend any decrease to the Enhanced Oil Recovery and Advanced Process Technology programs.

Sincerely,

David L. Morrison
President

DLM/ja

INTERSTATE OIL COMPACT COMMISSION

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Governor of Texas
Joint Chairmen

W. TIMOTHY DOWD
Executive Director

March 12, 1985

Representative Dave McCurdy
U. S. House of Representatives
313 Cannon Building
Washington, DC 20515

Dear Representative McCurdy:

I would appreciate your assistance by including the following brief statement in the record before the House Science and Technology Committee on the authorization bill for fossil energy research:

One of the greatest problems this country could face, although it is not often recognized, is what avenues can be taken should a long-term interruption of oil imports occur. More than 30% of this nation's oil consumption is from foreign sources; the last fifteen years have proven that this source can be painfully unreliable and dramatically impact the lives of American citizens.

The Strategic Petroleum Reserve can be expected to offset such interruptions for only a matter of months, and this service would not be available to supply nonessential needs which are present during normal periods of supply. Synthetic fuels are still largely in the experimental stages, and are likely to be ten or more years from commercial usage. With the current disagreements in the Congress and the Administration over the role and funding of the Synthetic Fuels Corporation, it is difficult to determine the availabiltiy of extensive synthetic fuels projects in the near future.

The major problem in the United States energy supply is the declining production of oil. Of the major oil producing states in the continental United States, only California's production has not declined in the last ten years. Thermal recovery has allowed California's production to remain constant; without it, the state would have experienced a decline as did the other major producers.

The Interstate Oil Compact Commission (IOCC) believes that the key to sustained U. S. oil supplies and a safeguard against interruptions in foreign oil sources lies in enhanced oil recovery (EOR). Presently, only 34% of the oil in place can be recovered using conventional methods. Of the 480 billion

MEMBER STATES ALABAMA · ALASKA · ARIZONA · ARKANSAS · CALIFORNIA · COLORADO · FLORIDA · ILLINOIS · INDIANA · KANSAS · KENTUCKY
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OKLAHOMA · PENNSYLVANIA · SOUTH DAKOTA · TEXAS · UTAH · VIRGINIA · WEST VIRGINIA · WYOMING
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barrels of oil known to be in place, 130 billion have been produced, 29 billion are proven reserves, and 18 billion are potential production from known EOR processes. Accordingly, over 300 billion barrels of oil represent a target for future EOR projects. If the percentage of recovery efficiency were increased by 1% to 35%, an additional 5 billion barrels would be produced.

An increase to 40% recovery would yield 30 billion barrels, equal to our current proven reserves. Given these figures, the importance of an intensive effort to develop new EOR technologies cannot be overestimated.

The National Petroleum Council (NPC) has recently completed a study of EOR potential nationwide. An extensive oil reservoir data base, containing two-thirds of known U.S. oil, and engineering models of production and economics were constructed for the analysis. Recovery estimates were based on available ("implemented") technology or improved ("advanced") technology, and technical performance was based upon field and laboratory-demonstrated engineering principles.

The estimates for recoverable oil range from 7 billion barrels from implemented technology to 34 billion barrels for advanced technology. EOR has the potential to increase the proven reserves anywhere from 25 to 120 percent. These results are generally consistent with previous EOR studies.

The critical element in obtaining the high levels of recoverable oil through advanced technologies lies with the availability of R & D dollars. Unfortunately, the federal government has allocated few dollars to this effort as compared to research monies for coal and nuclear fuel. In view of the time constraints necessary to develop any new EOR technologies, the Congress should recognize the vital role that EOR must play in energy independence efforts.

The data bases and models used in the NPC study are maintained by the Bartlesville Project office (BPO) of the Department of Energy's Office of Fossil Energy. The BPO has been assigned to assist the producing states in attempts to analyze EOR potential, and will work through the IOCC to provide this assistance. The IOCC has been a leading organization for the past fifty years to encourage the conservation of oil and gas resources and maximize recoverable levels of these fuels.

The producing states are keenly aware of the impact of oil and gas production on their states'economies. Reductions in production have wrecked havoc in some state economies, causing reductions in employment and revenues received through oil and gas severance taxes. This is to the advantage of those states to be apprised of the potential benefits of EOR technology for their states, as the impacts would be most surely felt on a local and state level rather than a national level.

Sincerely,

W. Timothy Dowd

WTD/lh

Summary of

Statement of Dr. Charles J. Mankin, State Geologist, State of Oklahoma

before the Subcommittee on Energy Development and Applications House Committee on Science and Technology

1. America is going out of the oil-production business -- production in the contiguous United States has declined steadily for 15 years: severely in several states, e.g., between 1972 and 1982:

- Louisiana	down 49%	- Texas	down 29%	- Nebraska	down 21%
- Mississippi	down 46	- Oklahoma	down 24	- Utah	down 16
- New Mexico	down 36	- Illinois	down 21	- Wyoming	down 16

o With falling oil prices, these declines have depressed these states' economies and tax bases, e.g., between 1982 and 1985, employment in oil extraction dropped 16% nationally -- 40,000 jobs in Texas; 27,000 in Oklahoma

o Without major improvements in technology, these declines can only continue, exacerbating the economic and fiscal problems of the producing states and the nation

2. But, America is not out of oil -- more than 300 billion barrels will be abandoned in known U.S. reservoirs:

- Texas	103 Bill.Bbls.	- Louisiana	22 Bill. Bbls.	- Wyoming	11 Bill. Bbls.
- California	62	- New Mexico	11	- Illinois	6
- Oklahoma	26	- Kansas	11	- Ohio	6

3. Enhanced oil recovery (EOR) processes are sophisticated technologies designed to produce this oil.

o The National Petroleum Council estimated EOR could add 7.4 to 34 billion barrels to the nation's reserves -- and up to 2.7 million barrels per day by 2000; state-level increases over current reserves could be massive, e.g.:

- New Mexico	up 170%	- Texas	up 104%	- Louisiana	up 68%
- Nebraska	up 151	- Utah	up 99	- Montana	up 60
- California	up 142	- Illinois	up 94	- Kentucky	up 54
- Oklahoma	up 128	- Florida	up 87	- Mississippi	up 51

o Such increases substantially benefit the economies and tax bases of these states and the nation as a whole, with corresponding improvements in U.S. trade balances and energy security

4. We have failed to achieve these massive benefits for three reasons:

o First, EOR is a high risk technology due to poor predictability of production.

-- Poor predictability is due to inadequate understanding of the rocks, fluids, and mechanisms of EOR as they interact in the reservoir.

-- Improved understanding requires basic, long-range research.

- o Second, industry cannot justify such fundamental, long-range research
  - -- Due to time-value of money, such long-range research has traditionally been done by universities and government.
  - -- Individual firms cannot capture the full benefit of these research investments because there is little to patent or license from fundamental understanding.
  - -- Industry's R&D focuses on site-specific problems of particular reservoirs, not fundamental research for common understanding.
- o Third, industry must seek the lowest cost reserves to compete successfully
  - -- At present, it is cheaper to buy or merge into new reserves than to apply risky EOR.
  - -- Industry can explore abroad for low-cost foreign oil cheaper than it can use risky EOR domestically.
- o The producing states and the nation, however, can neither merge into new reserves nor find them abroad; if EOR can be made less risky, it will be used -- we now produce almost 600 thousand barrels per day from uniquely predictable reservoirs.

5. The DOE Fossil Energy program in EOR research addresses precisely the areas where inadequate understanding most undermines predictability:
   - o Fundamental, long-range R&D that industry cannot justify, to improve predictability and control enough to reach acceptable risk levels field.
   - o Creating a common, public base of understanding that can be applied to reduce the risks in numerous particular settings.
6. Therefore, I could readily recommend a substantial increase -- even doubling -- in funding for this excellent program.
   - o Petroleum accounts for 43% of U.S. energy but only 0.3% of DOE's non-defense R&D, a major imbalance.
   - o The current program's funding level prohibits needed intensive state-oriented research and in-depth, empirical post-project assessments and is minimal in other important areas.
7. However, in light of present federal budget situation, the Administration's request of $10.6 million (plus $1.4 million for tar sands) is adequate -- but just barely.
8. This level of funding must be maintained for America to stand a chance of staying in the oil-producing business, with important benefits to the producing states and the nation as a whole.

Statement of Dr. Charles J. Mankin
State Geologist, State of Oklahoma
before the
Subcommittee on Energy Development and Applications
House Committee on Science and Technology

March 6, 1985

Mr. Chairman and Members of the Subcommittee:

America is going out of the oil-production business. Despite two major price increases, domestic production (excluding Alaska) has declined steadily for 15 years, creating a vulnerability to import interruptions and contributing to our negative trade balances. The rising prices, however, served to mask the production decline economically, even creating a temporary "boom," in 1979-81. Since then, however, both prices and production have been in decline. The resulting severe economic dislocation and unemployment in many of the major oil-producing states has created major hardships on families and companies and has necessitated emergency tax increases and reductions in services to maintain state budget integrity. Federal royalties and taxes, likewise, have decreased, contributing to the current deficit.

We may be going out of the oil-producing business, but we are not out of oil. Not at all. In fact, twice as much oil will remain unproduced in known U.S. reservoirs than we have produced or can hope to produce using conventional technology. That amounts to more than 300 billion barrels expected to be left in the ground — about 100 times current annual production. This "residual" oil is trapped or by-passed by conventional recovery techniques in use today.

Sophisticated new technologies, collectively called enhanced oil recovery (EOR), hold the promise of making an important portion of this residual oil producible. If we could increase our recovery efficiency from the current average of 34 percent by just one percent -- to 35 percent -- we would be richer by almost 5 billion barrels, about two years of Lower-48 production. An increase of six percent -- to 40 percent overall -- would yield nearly 30 billion barrels, more than our currently proved reserves. A recent, in-depth study by the National Petroleum Council has shown improvements in this range are highly feasible. Such production could significantly improve our energy security, trade balances, the domestic economy, and the treasuries of the producing states and the federal government.

These technologies, however, are currently very costly and unpredictable. The resulting high risks make them less attractive to industry than other investment options. Highly focused research and development would improve performance and lower costs and risks. Industry, of course, will provide the major portion of the needed R&D when economic and competitive conditions so justify. This may take many years -- during which time the producing states' problems can only get worse. An important facet of this R&D, however, is necessarily provided by the public sector: this is the portion that addresses distinctively public issues and will require coordinated state-federal actions to bring it about.

I am here to express the vital interests of the producing states in seeing that an appropriate level of publicly oriented R&D funding for enhanced oil recovery is authorized and appropriated.

Economic Impact of Declining Oil Production

Oil production from the contiguous United States has declined 25% over the past decade; the decline has been severe in the major, mature producing states (Figures 1 and 2).

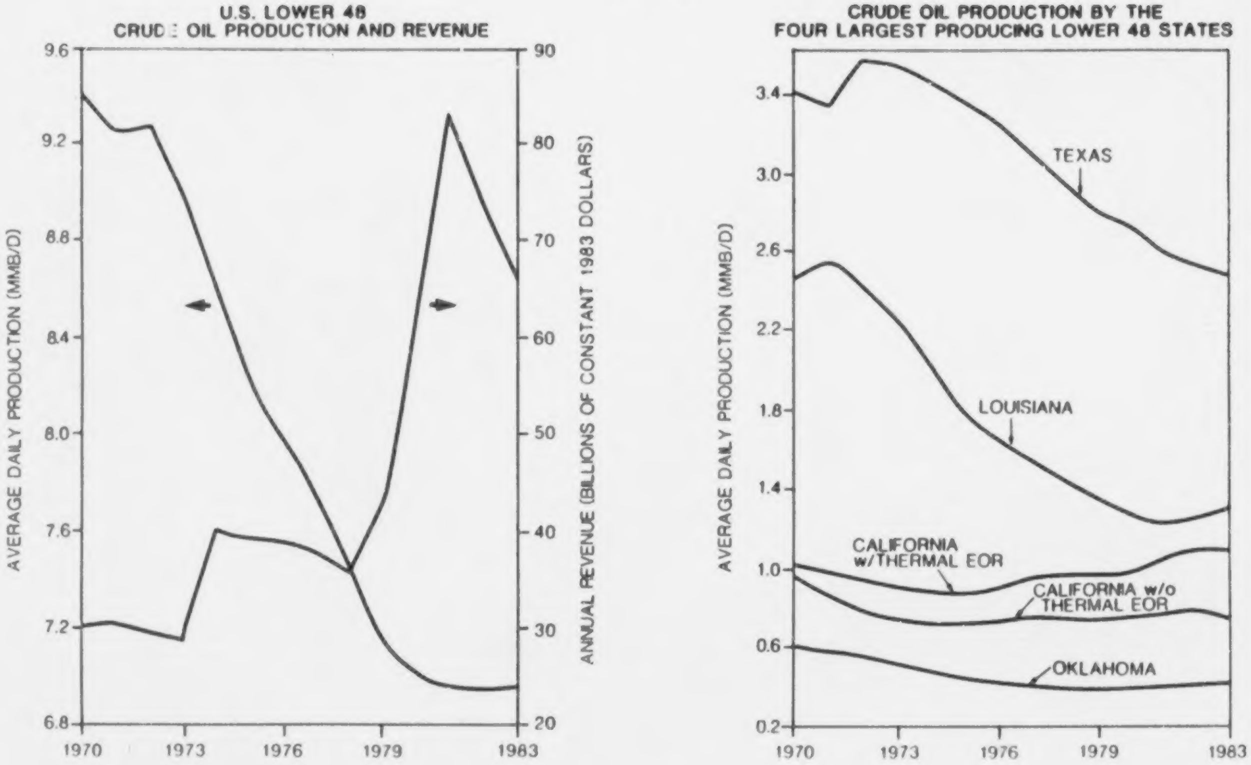
Consider the following statistics for a moment:

OIL PRODUCTION DECLINE (1972-1982)

Louisiana	down 49%	Illinois	down 21%
Mississippi	down 46	Nebraska	down 21
New Mexico	down 36	Utah	down 16
Texas	down 29	Wyoming	down 16
Oklahoma	down 24	Montana	down 9

All major producing states except California (assisted by thermal enhanced oil recovery) and Alaska (supported by the largest and one of the newest fields in the Western Hemisphere) have suffered significant production declines over the past decade. Even where production has not yet declined.

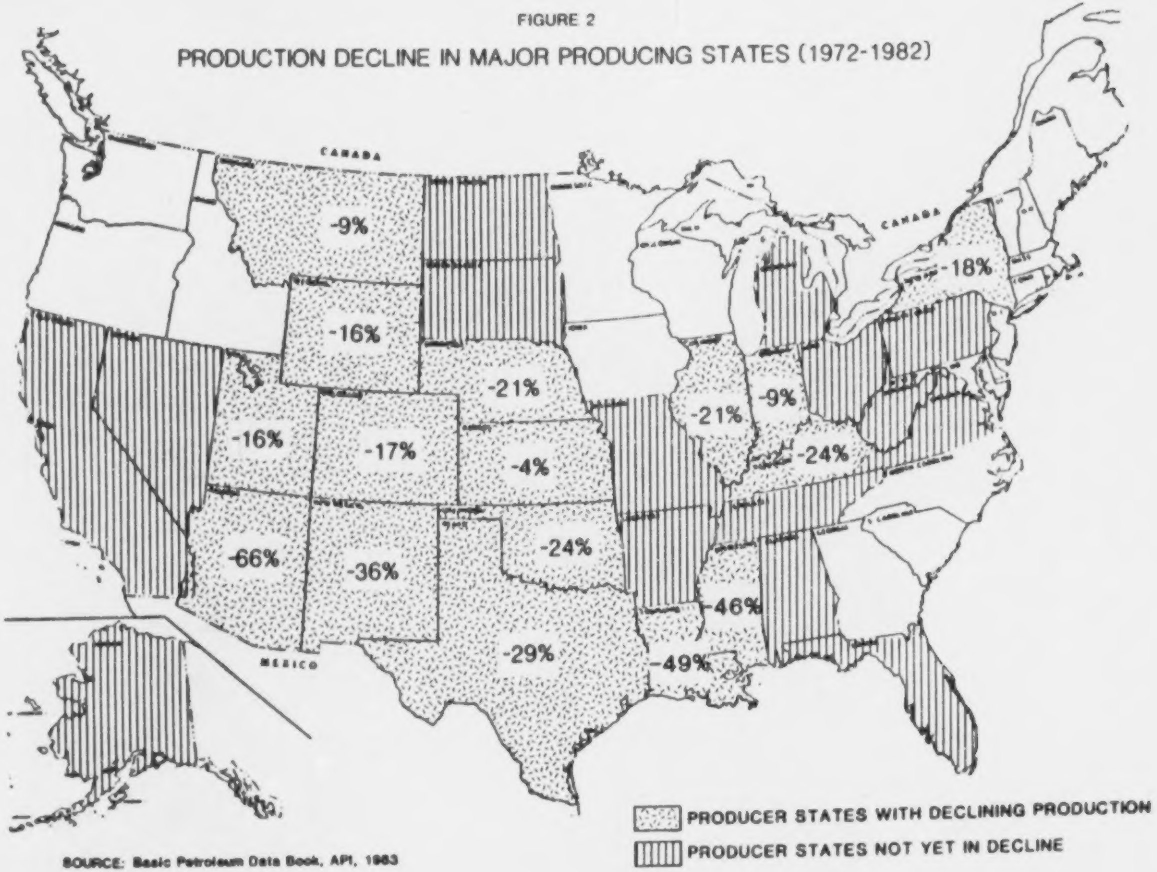
FIGURE 1



SOURCES: American Petroleum institute, 1985, Energy Information Administration, 1980, 1981, 1982, California Oil Producers, 1981, Oil and Gas Journal, April 5, 1982

FIGURE 2

PRODUCTION DECLINE IN MAJOR PRODUCING STATES (1972-1982)


CANADA
CANADA
MEXICO
-9%
-16%
-21%
-16%
-17%
-4%
-66%
-36%
-24%
-29%
-21%
-9%
-24%
-46%
-49%
-18%
PRODUCER STATES WITH DECLINING PRODUCTION
PRODUCER STATES NOT YET IN DECLINE

SOURCE: Basic Petroleum Data Book, API, 1983 reserves have declined, meaning that production will shortly decline as well. For the nation as a whole, reserves declined by 17% over the eight years (1976 to 1983). These declines are often overlooked in viewing national energy statistics, but are quite real and will continue into the foreseeable future.

The reserves decline would, in fact, have been much steeper if we had relied on exploration to maintain them. Higher prices have justified infill drilling, drilling of thinner portions of reservoirs, and continuing production of marginal "stripper" wells. These activities appear as additions to reserves through "revisions" and "extensions." Since 1977 revisions and extensions have accounted for 85% of all reserve additions, whereas new fields and new reservoir discoveries have added only 15%. This small contribution from new fields and new pools accrued while drilling for these targets nearly doubled. The significance of this is that, with falling oil prices, fewer reserve additions will come from revisions and extensions. Moreover, there is a natural limit to which infill drilling, etc., can continue to increase reserves.

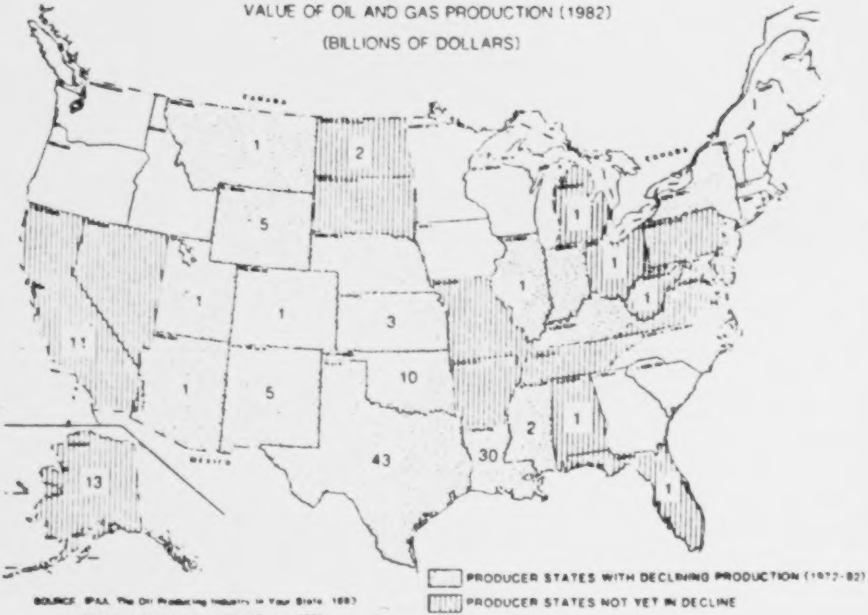
Further, while we are drilling increasing numbers of exploratory wells, we are finding smaller and smaller fields. In 1972, 22% of the new fields discovered were larger than one million barrels. By 1979, only 3% were this large and the proportion has not exceeded 4% since. The continued decline in domestic production, then, seems assured as we find fewer and smaller new fields discovered through much greater effort and as we exhaust the options for revisions and extensions.

Even with these production declines, oil revenue has, until recently perhaps, continued to be a significant contributor to the economic health of the producing states (Figure 3). In 1982, twenty states had oil and gas production of more than $1 billion, seven had more than $5 billion. With falling prices and production, current and near-term estimates will be lower.

Petroleum production is also critical to the finances of several producing states. As Figure 4 shows, eight states (in 1982) depended on petroleum taxation for 10% or more of their revenues. Examination of those

FIGURE 3

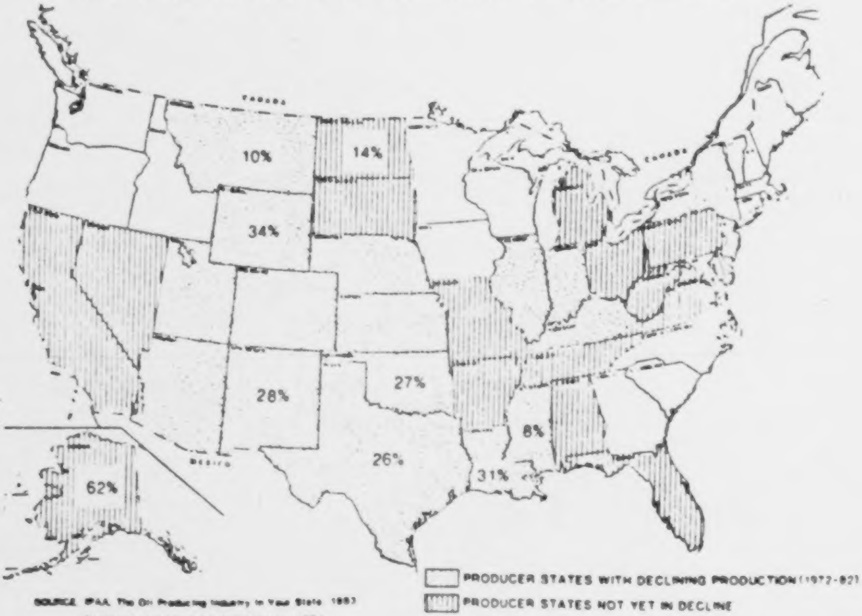
VALUE OF OIL AND GAS PRODUCTION (1982)
(BILLIONS OF DOLLARS)


CANADA
1
2
5
1
1
3
11
10
1
5
43
30
2
1
1
1
1
1
13
MEXICO
PRODUCER STATES WITH DECLINING PRODUCTION (1972-82)
PRODUCER STATES NOT YET IN DECLINE

SOURCE: IPAA, The Oil Producing Industry in Your State, 1983
Statistical Abstract of the United States, 1984

FIGURE 4

PROPORTION OF STATE TAX REVENUES DERIVED FROM PETROLEUM PRODUCTION (1982)


CANADA
10%
14%
34%
28%
27%
26%
31%
8%
62%
MEXICO
PRODUCER STATES WITH DECLINING PRODUCTION (1972-82)
PRODUCER STATES NOT YET IN DECLINE

SOURCE: IPAA, The Oil Producing Industry in Your State, 1983
Statistical Abstract of the United States, 1984

states already described as having serious declines shows that many of them have petroleum as a key to their tax bases:

PETROLEUM REVENUE AS PERCENT OF STATE TAX BASE (1982)

Louisiana	31%	Illinois	n.a.
Mississippi	8	Nebraska	1
New Mexico	28	Utah	2
Texas	26	Wyoming	34
Oklahoma	27	Montana	10

Long term production declines, coupled with more recent falling prices have not only reduced economic activity and tax bases of the producing states, they have had direct impact upon their citizens. In just one year -- 1982-83, -- direct employment in petroleum extraction dropped 15.5% nationwide. This drop in employment has been extraordinarily widespread (Figure 5), including both states with severe production declines and states that have not yet experienced major declines. In states we have been highlighting, the reductions were more severe:

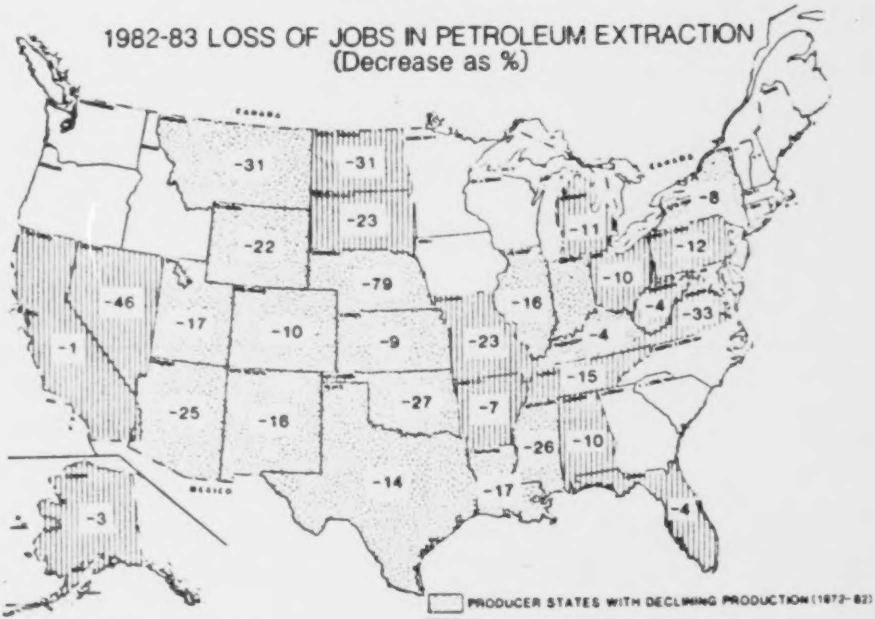
REDUCTIONS IN JOBS IN PETROLEUM EXTRACTION (1982 to 1983)

Louisiana	down 17%	Illinois	down 16%
Mississippi	down 26	Nebraska	down 79
New Mexico	down 16	Utah	down 17
Texas	down 14	Wyoming	down 22
Oklahoma	down 27	Montana	down 31

These include only those people directly engaged in petroleum extraction. Additional jobs in petroleum service industries, retail, service, and financial institutions, and the general local economies are, of course, also affected. In brief, declining production and falling prices are sustaining a recession in the oil-producing business that is severely threatening the economies, treasuries, and people of the producing states and slowing the national recovery.

My own state of Oklahoma is a prime example of the problems caused by these production declines. From 1982 to 1983, employment in petroleum extraction dropped from 102 thousand to 75 thousand jobs. The only reason our overall unemployment has remained reasonable is that the most able and ambitious of these individuals have followed an Oklahoma tradition dating back

FIGURE 5



1982-83 LOSS OF JOBS IN PETROLEUM EXTRACTION
(Decrease as %)

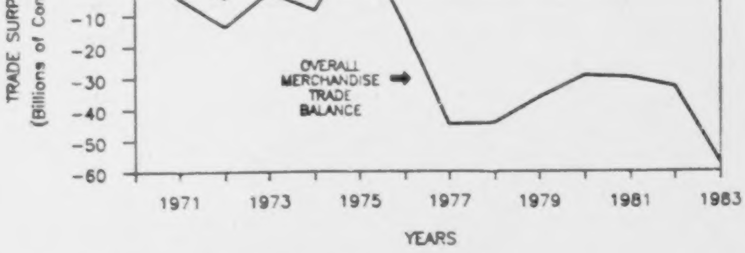
CANADA
MEXICO
-31
-31
-23
-22
-8
-11
-12
-79
-46
-16
-10
-17
-10
-9
-23
-4
-4
-33
-1
-15
-27
-7
-25
-18
-26
-10
-14
-17
-3
-4
PRODUCER STATES WITH DECLINING PRODUCTION (1972-82)
PRODUCER STATES NOT YET IN DECLINE

SOURCE: IPAA, "The Oil & Gas Producing Industry in Your State 1984"

NOTE: National Average: 16.9% decrease

FIGURE 6

MERCHANDISE TRADE BALANCE
WITH AND WITHOUT PETROLEUM IMPORTS



SOURCE: Statistical Abstract of the United States, 1985, 105th Edition;
U.S. Department of Commerce. Bureau of Census.

to the dustbowl and the Grapes of Wrath -- they "moved on" to opportunities elsewhere. Oklahoma oil production has declined 24% in the last decade. In 1982, oil and gas production still accounted for $10.3 billion in economic activity and 27% of state tax revenues. Between 1982 and 1983 alone, state severance and production revenues dropped by $35 million. This, coupled with the loss of 27,000 jobs in the same period has led to significant hardship for the state and its people. Oklahoma has already passed special "temporary" taxes and has significantly reduced public services. An example near to my heart is that most faculty salaries in our state universities have not been raised in three years, and a fourth is looming. As taxes rise, as many of our most energetic and talented people "move on," and as services deteriorate, it will be increasingly difficult to attract the new industry needed to augment the rapidly declining oil-based economy. As Oklahoma wells and fields are abandoned, some 26 billion barrels of residual oil will also be abandoned. Abandonment increases the economic burden of reopening these fields to improved recovery technology, itself currently an economically tenuous proposition at best. The Oklahoma experience is being, or soon will be, repeated throughout all the major oil-producing states. In a real sense, we run the risk of becoming "Appalachia West," chronically depressed. The maps in the exhibits show how widespread the problem has become. As I said earlier, unless some significant changes are made, America is going out of the oil-production business.

The national picture, more than simply the aggregate of these state problems, is also bleak. Our reliance on imports, as a proportion of consumption is nearly where it was at the time of the embargo -- 36% in 1973 compared with 33% in 1983. Since 1972, U.S. negative merchandise trade balances can be attributable almost entirely to petroleum imports (Figure 6). In 1983, we had a negative merchandise trade balance of $57.5 billion, of which petroleum imports made up 91%. Declining U.S. production is the principal cause. Beyond these problems of energy security and trade deficits, however, the overall national recovery has been slowed and federal revenues reduced by the loss of royalties from public lands and taxes from petroleum producing companies.

The cause of the problem is the maturity of the nation's oil fields. We have produced all the "easy oil" but two thirds of all the oil we have discovered remains in the reservoirs, awaiting more sophisticated, costly, and risky technologies. Unless these technologies can be brought to bear -- and soon -- many of the oil producing states will face severe economic declines.

Oil Abandoned in Known Reservoirs

Also, as I said at the beginning of my statement, while we appear to be going out of the oil-producing business, we are not out of oil. Conventional production techniques recover only about one third of the oil that is actually in the nation's reservoirs. In all, we have discovered about 480 billion barrels of oil in the U.S. The following accounts for it:

Discovered in U.S.	480 Billion Barrels
Produced through 1983	-133
Remaining Proved Reserves	- 28
"Residual" Oil Remaining in U.S. Reservoirs	319

That's right. More than 300 billion barrels of liquid petroleum -- nearly ten trillion dollars' worth -- will be abandoned unless we do something about it. In looking at the amounts of oil that may be abandoned in the states previously identified as having serious declines as well as in other major producing states, we see the magnitude of the resource at issue:

OIL REMAINING IN RESERVOIRS AT THE TIME ABANDONMENT

States in Severe Production Decline

Louisiana	22 Billion Bbls	Illinois	6 Billion Bbls
Mississippi	3	Nebraska	1
New Mexico	11	Utah	3
Texas	103	Wyoming	11
Oklahoma	26	Montana	4

States Not Yet in Serious Decline

California	62	Kansas	11
Alaska	19	Ohio	6

Clearly, the states that most rely on their petroleum resources for their economic and tax base also have the most oil left to produce -- if enhanced oil recovery technologies can be developed to produce it. These technologies can be developed. The evidence is compelling and the potential, which we shall now address, is enormous.

Potential of EOR: The National View

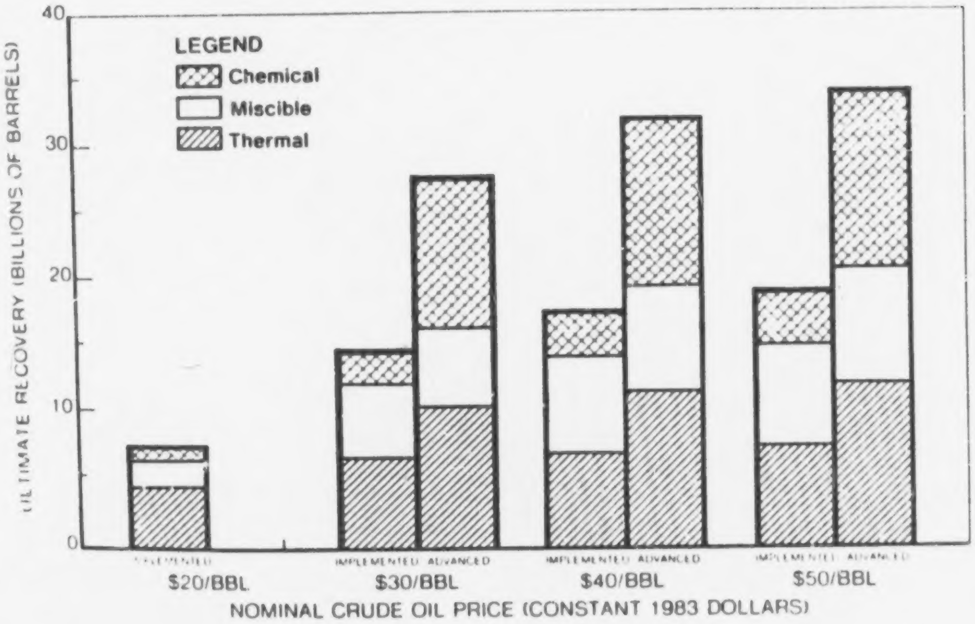
The National Petroleum Council (NPC), the advisory committee to the Secretary of Energy, recently completed an in-depth, two-year study of the potential of EOR nationwide. The study committee was comprised of more than 100 leading EOR experts from all the major producers, numerous independents, engineering and oil field service companies, universities, and the federal government. An extensive oil reservoir data base (containing two-thirds of all known U.S. oil) and detailed engineering models of production and economics were constructed for the analysis. A generally conservative methodology was followed in analyzing each individual reservoir's enhanced recovery potential and cost. Recovery estimates were based on either available ("implemented") technology or improved ("advanced") technology. In both bases, technical performance was based on engineering principles that had been demonstrated in field and laboratory tests.

Figure 7 shows the amount of oil estimated to be recoverable by EOR methods. They range from a low of 7.4 billion barrels (for the "implemented" technology at a $20/barrel oil price) to 34 billion barrels (for the "advanced" technology at $50/barrel). That is, EOR has the potential of adding at least a 25 percent -- but as as much as a 120 percent -- increase to current U.S. proved reserves. Even at its lower limit, this is a massive quantity of additional domestic production. Achieving the "advanced" level of technology will require substantial investments in R&D but will yield by far the greatest quantities of reserves.

Figure 8 shows the timing of this incremental production. Depending on oil prices and the level of available technology, incremental EOR production might increase anywhere from only slightly over its current level (about 600

FIGURE 7

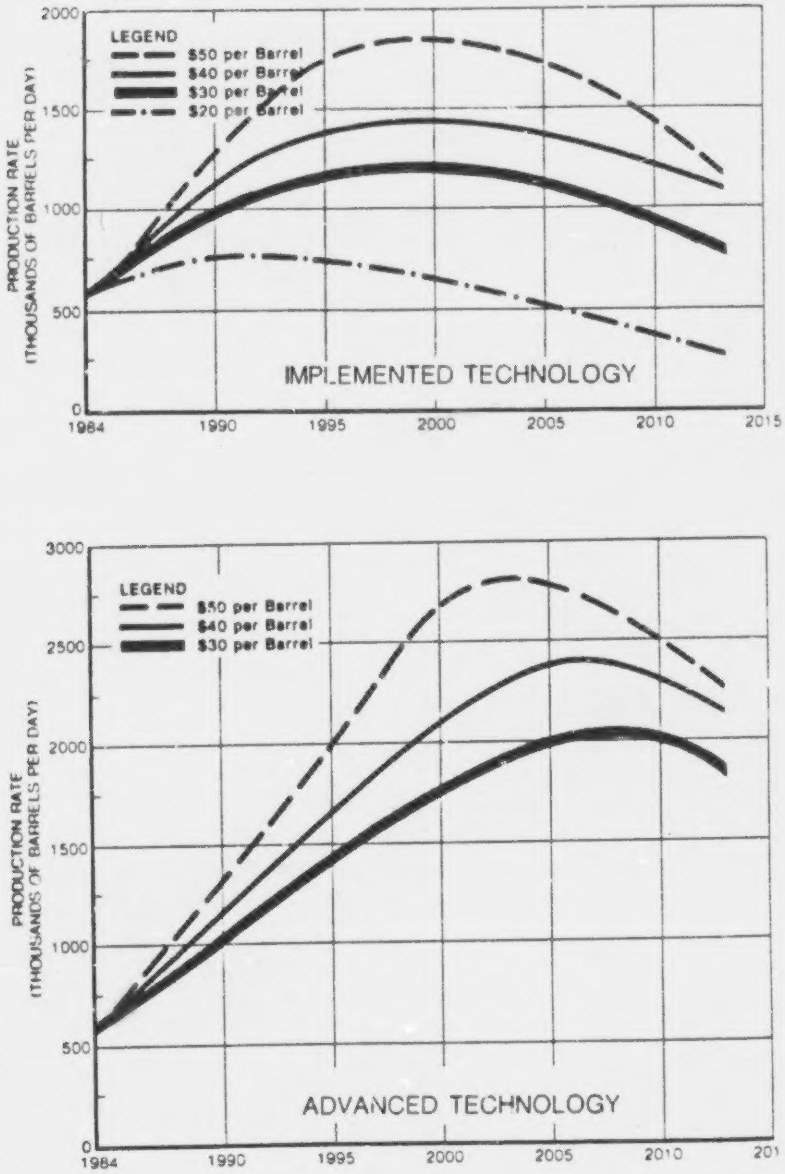
ESTIMATED ULTIMATE RECOVERY OF ENHANCED OIL RECOVERY
(By Technology Level and Price)



SOURCE: NPC, 1984

FIGURE 8

ESTIMATED PRODUCTION RATES FOR ENHANCED OIL RECOVERY



SOURCE: NPC, 1984

thousand barrels per day) to nearly 2.8 million barrels per day. As with ultimate recovery, these estimates again underline the extreme importance of achieving the "advanced" technology through R&D.

These results are consistent with all the prior EOR studies, including the NPC earlier assessment (1976), Lewin and Associates (1976 and 1978), and the Congressional Office of Technology Assessment (1978). All of these evaluations used detailed, reservoir-specific data and modeling approaches and all have concluded that EOR has potential in the range estimated by the latest NPC study. All these studies have also emphasized the critical need for R&D to achieve the full potential of EOR.

EOR and the States

The data bases and models used in the NPC study are currently being maintained by the Department of Energy Bartlesville Project Office (BPO) of the Office of Fossil Energy. BPO is also responsible for planning and managing the federal research program in EOR. (To clarify a point that has caused some confusion, the BPO is the federal office that remains in Bartlesville. It is not to be confused with the National Institute for Petroleum and Energy Research (NIPER), a division of the private, non-profit IIT Research Institute which operates the federal facility at Bartlesville and performs a portion of the federal petroleum research program under cooperative agreement with DOE.)

The Office of Fossil Energy has agreed to assign BPO to assist the states in their desire to analyze EOR potential and opportunities at the state level. To avoid duplication, BPO has concentrated this assistance through the Interstate Oil Compact Commission. The IOCC is the organization of the governors of the producing states. For the past 50 years, it has pursued its charter of resource conservation -- maximizing the recovery of oil and gas. Out of the cooperation between IOCC and BPO have come preliminary state-level analyses of the potential impact of EOR on the states' economies and tax bases. The analysis used the NPC data base and models in the "implemented" technology mode for a conservative assessment and assumed a $30/B nominal oil price. The IOCC, unlike the NPC, extrapolated the results to allow for reservoirs missing from the data base.

The results of the analysis show that, even under "implemented" technology, EOR has the potential to make substantial contributions to states with declining oil production. Estimated potential additions to reserves by EOR for each state are displayed in Figure 9. Five states' reserves would be increased by more than one billion barrels and those of fifteen states would be increased by at least 100 million barrels. The significance of these potential reserves is, perhaps, most easily seen by relating them to the currently proved reserves of each state. The percentage increase in reserves is shown in Figure 10. Even under conservative assumptions, EOR could more than double current proved reserves in six states; in seven more it could increase reserves by more than 50%. A reexamination of the list of states with severe production declines underlines this conclusion:

Percentage Increase in Reserves Due to EOR

States in Severe Production Decline

Louisiana	up 68%	Illinois	up 94%
Mississippi	up 51	Nebraska	up 151
New Mexico	up 170	Utah	up 99
Texas	up 104	Wyoming	up 39
Oklahoma	up 128	Montana	up 60

Other States With Significant Proportional Gains

California	up 142	Kentucky	up 54
Florida	up 87	Arkansas	up 44

Producing these reserves would, of course, create significant economic activity and generate substantial tax revenues to the producing states (as well as to the federal government). As shown in Figure 11, EOR could directly stimulate one billion dollars or more in production in 14 states, and more than $10 billion in eight states. These estimates include only the direct sale price of the incremental oil; they do not include secondary economic effects.

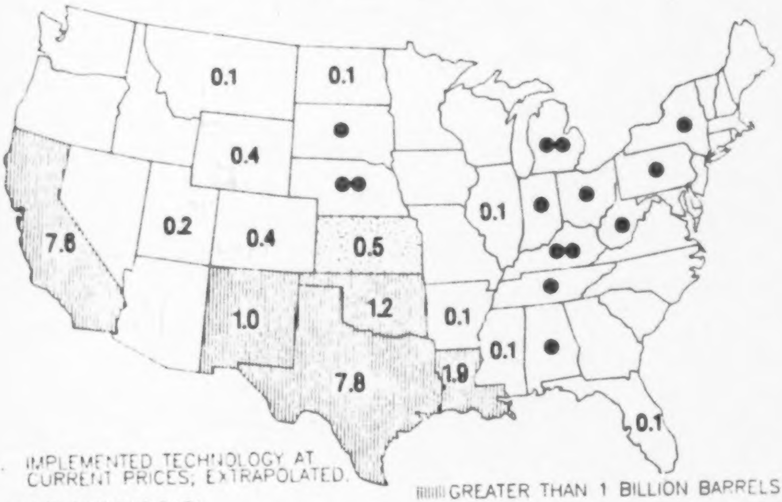
The corresponding impact on state and local taxes is exhibited in Figure 12. Sixteen states would receive more than $100 million in production and income taxes; six of them would receive more than one billion dollars. More importantly, essentially all of the states with significant reliance on

FIGURE 9

PRELIMINARY

POTENTIAL EOR RESERVES — 'IMPLEMENTED TECHNOLOGY'¹

(BILLION BBLS)


0.1
0.1
0.4
0.2
7.6
0.4
0.5
0.1
1.0
1.2
0.1
0.1
1.9
7.8
0.1

1. IMPLEMENTED TECHNOLOGY AT CURRENT PRICES; EXTRAPOLATED.

● INSUFFICIENT DATA
●● LESS THAN 0.05 BILLION BARRELS

▥ GREATER THAN 1 BILLION BARRELS
░ GREATER THAN 0.5 BILLION BARRELS

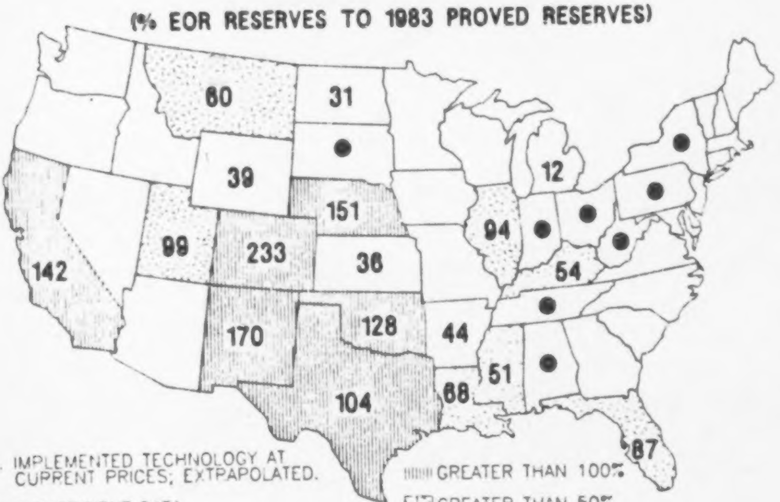
SOURCE IOCC 1984

FIGURE 10

PRELIMINARY

INCREASE IN RESERVES ATTRIBUTABLE TO EOR 'IMPLEMENTED' TECHNOLOGY ¹

(% EOR RESERVES TO 1983 PROVED RESERVES)


60
31
39
12
151
99
233
94
36
142
54
170
128
44
51
104
68
87

1. IMPLEMENTED TECHNOLOGY AT CURRENT PRICES; EXTRAPOLATED.

● INSUFFICIENT DATA

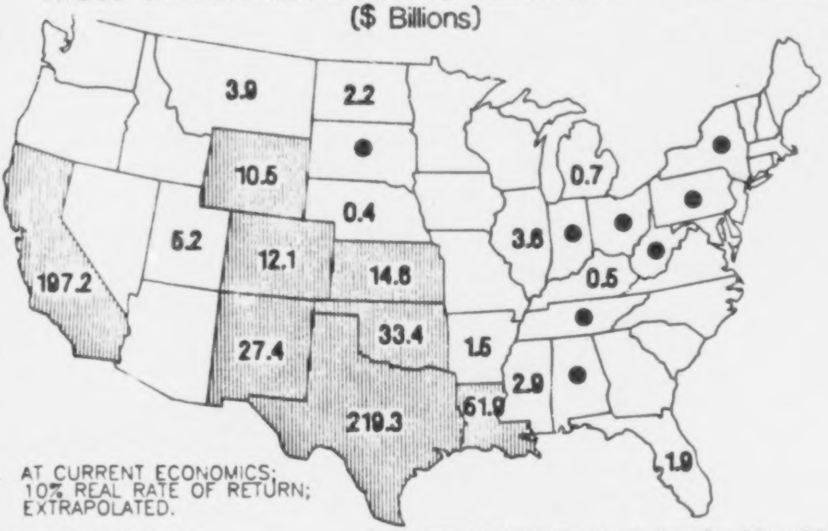
▥ GREATER THAN 100%
░ GREATER THAN 50%

SOURCE IOCC 1984

FIGURE 11

PRELIMINARY

VALUE OF OIL FROM EOR – 'IMPLEMENTED' TECHNOLOGY
($ Billions)


3.9
2.2
●
10.5
0.4
6.2
12.1
14.6
197.2
27.4
33.4
1.5
219.3
61.9
2.9
●
1.9
3.6
●
●
0.7
0.5
●
●
●
●

1. AT CURRENT ECONOMICS; 10% REAL RATE OF RETURN; EXTRAPOLATED.

● INSUFFICIENT DATA

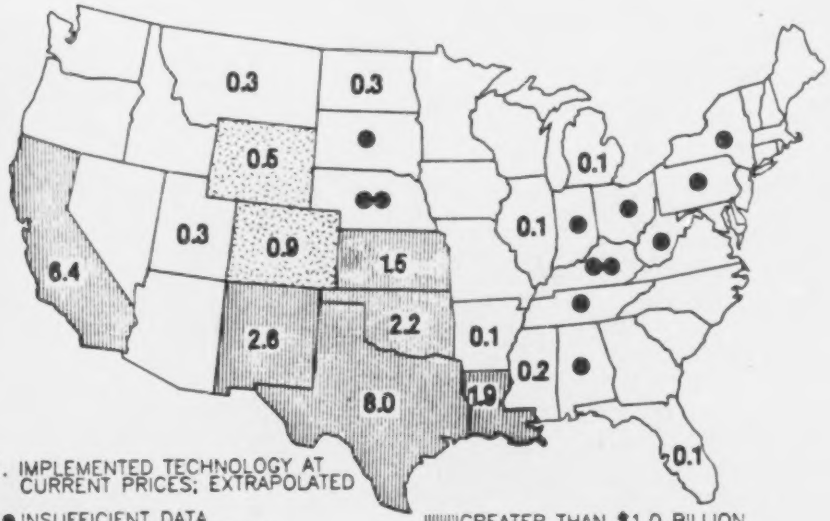
▥ GREATER THAN 10 BILLION DOLLARS

SOURCE: IOCC, 1984

FIGURE 12

PRELIMINARY

STATE AND LOCAL TAXES STIMULATED BY EOR – 'IMPLEMENTED' TECHNOLOGY [1].


0.3
0.3
●
0.5
●●
0.3
0.9
1.5
6.4
2.6
2.2
0.1
8.0
1.9
0.2
●
0.1
0.1
●
●
●●
0.1
●
●
●
●

1. IMPLEMENTED TECHNOLOGY AT CURRENT PRICES; EXTRAPOLATED

● INSUFFICIENT DATA
●● LESS THAN $0.05 BILLION

▥ GREATER THAN $1.0 BILLION
▨ GREATER THAN $0.5 BILLION

SOURCE: IOCC, 1984

petroleum for their tax bases would benefit (compare Figure 12 with Figure 4, earlier). On a national basis, approximately one dollar per barrel of EOR production is a reasonable estimate of state tax revenues.

To look at Oklahoma again, EOR could add more than 1.2 billion barrels of reserves, which would more than double our current level. Assuming the nominal oil price of $30 B, this would add $33.4 billion directly to our economy, not including indirect additions. Finally, $2.2 billion in state taxes would be generated directly. With estimates of increased reserves and revenues of this magnitude, you can understand my enthusiasm for EOR.

Although such benefits in economic activity and tax revenues would extend over a period of thirty years or more, these estimates are based on the use of technology that the NPC considered "implemented" or essentially available today, and an oil price of $30 B. Despite the current price slump, most energy economists expect oil prices to firm and rise in real terms over the next decade. Further, improved recovery efficiency could make fields that are now uneconomically small into viable production projects; these options were not considered in the study. More important, however, is that substantially greater benefits could be achieved if research and development can realize the "advanced" technology. As the earlier Figure 7 showed, these benefits could almost double with the "advanced" technology at any given price level.

An additional benefit of EOR could be realized in even more directly improving our energy security posture: with some effort, EOR could be a direct hedge against import interruptions that last longer than the capacity of the Strategic Petroleum Reserve.

Many of you will recall our desperate need for aviation fuel during World War II. What you might not know is that the Government had, and still maintains as part of the oil program, a data base on the properties of oil contained in oil reservoirs. During the war, that data base was used to pinpoint fields whose oil would yield the greatest amount of aviation fuel. Priority was then given to materials needed to develop these fields, and it worked.

Enhanced oil recovery can be viewed in much the same manner. In a real emergency, the Strategic Petroleum Reserve is expected to contribute to supplies in the short term, measured in months. Synthetic fuels can only be developed in quantity at great cost over an extended period, five to ten years. Enhanced oil recovery is an intermediate option that can be applied to specific reservoirs identified from the Government data base. After the exhaustion of the Strategic Reserve, our only significant options are the Rapid Deployment Force and instant diplomacy, extreme options indeed. The normal lead time for enhanced recovery from start to significant production is three to eight years. This lead time, however, could be reduced to one to two years if the data base were augmented with a specific pre-engineering program to test specific processes in candidate fields. Such low-cost pre-engineering, done in collaboration with the field operators, could substantially enrich the nation's options in such times.

Constraints on Enhanced Recovery

Clearly, if declining domestic oil production is the problem, EOR is uniquely the solution. Currently available technology, if implemented, can provide major benefits. Advanced EOR technology, available only through R&D, can add even more significantly to reserves, production, jobs, economic activity, and tax and royalty revenues for the producing states and for the nation. At the same time, this domestic production would reduce our negative trade balance -- imported petroleum cost us $52.3 billion in 1983 -- and vulnerability to import disruptions, whatever the resolution to the current strategic reserve issues.

Despite these benefits, EOR production has been slow to develop and EOR research has been limited. There are several reasons for this. First, EOR processes entail high risks due to two factors: high front-end costs and a low level of predictability of oil production. Of the two, poor predictability appears to be the more significant. In the period 1979-81, oil prices more than doubled and special "front-end" incentives (through price relief and lowered Windfall Profit Taxes) were made available for EOR. These were expected to stimulate EOR production significantly. As Figure 13 shows, however, EOR production increased only very slightly. Thus, the risks due to

FIGURE 13

DESPITE A SHARP RISE IN OIL PRICES AND SPECIAL ECONOMIC INCENTIVES, EOR PRODUCTION HAS REMAINED LIMITED

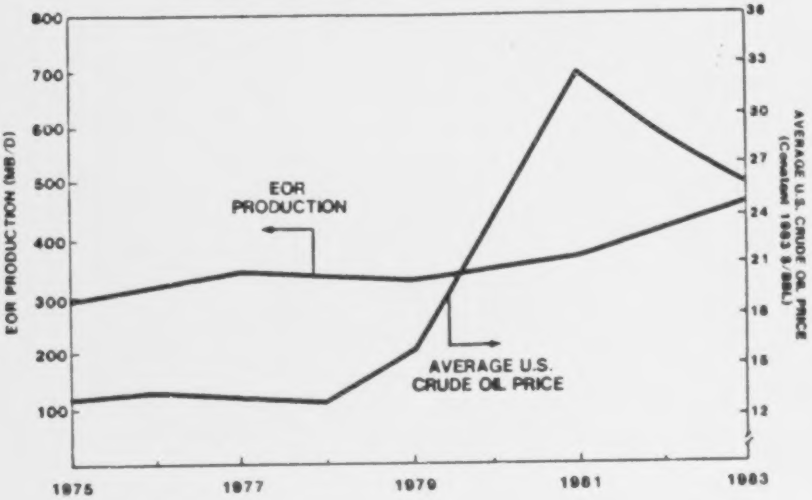
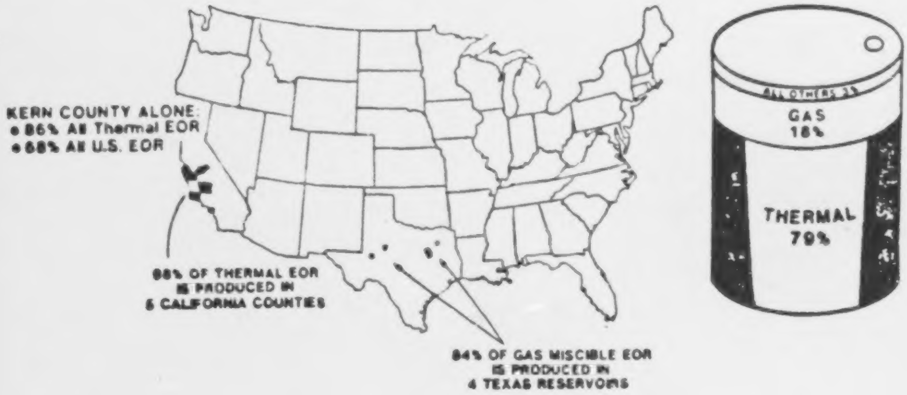


FIGURE 14

CALIFORNIA STEAM DRIVES ACCOUNT FOR ESSENTIALLY ALL CURRENT EOR PRODUCTION


KERN COUNTY ALONE:
• 86% All Thermal EOR
• 68% All U.S. EOR
88% OF THERMAL EOR IS PRODUCED IN 5 CALIFORNIA COUNTIES
84% OF GAS MISCIBLE EOR IS PRODUCED IN 4 TEXAS RESERVOIRS
ALL OTHERS 3%
GAS 18%
THERMAL 79%

poor predictability are still too high to permit economic benefits alone to stimulate EOR production.

Poor predictability derives from the presently inadequate fundamental understanding of the resource itself (how the residual oil is trapped, where it resides in the reservoir, and properties of the reservoir rock and fluids) and of the EOR processes (the basic mechanisms for displacing and mobilizing the residual oil). Understanding of both the resource and the processes for producing it can be improved through basic, focused R&D. Improved understanding leads to an increased ability to predict and, therefore, design and control cost-effective EOR technologies.

In certain, uniquely favorable reservoirs, adequate predictability has already been achieved. These account for essentially all current EOR production. The marked geographic concentration of current EOR production (Figure 14) underscores the uniqueness of these settings. Kern County, California alone accounts for two-thirds of all U.S. EOR production. Nine counties (five in California and four in Texas) together account for 93% of the U.S. total. Additional production can be expected from west Texas and eastern New Mexico as major pipelines are now being completed to bring carbon dioxide into the Permian Basin for EOR projects. For thermal recovery in California and gas flooding in the Permian Basin, predictability is adequate to justify substantial investments. Other regions, with massive amounts of residual oil, have not been so favored.

A second reason EOR technology has not been developed very rapidly relates to limited amounts of EOR research. Corporate time-value of money constraints have tended to discourage long-range, high-risk research of the sort needed to improve basic understanding and predictability. Such fundamental research has typically been the province of universities and government. Further, EOR expertise and R&D capabilities are limited to a few large producing companies. Even within these companies, this valuable asset tends to be employed in the solving of highly specific, immediate problems of particular reservoirs, rather than fundamental scientific inquiry. The needed improvements in understanding offer very little that can provide direct competitive advantage through patents, licenses, or trade secrets. And, finally, smaller firms and independents simply cannot afford the "overhead" of research facilities.

A third reason for limited investments in EOR is that, in the best interests of their stockholders, producers must seek the lowest cost reserves available. At present, it is cheaper to buy or merge into new reserves than it is to use high technology to create them. It is also cheaper to explore and find reserves abroad than to implement EOR at home. Unfortunately, the producing states and the nation can neither merge into new reserves nor find them abroad. Mergers and foreign exploration cannot provide relief from the long-term decline in domestic production.

Thus, the very fundamental unknowns of the residual oil resource and its potential production technologies, coupled with more attractive alternative investments, have constrained EOR research and applications despite the substantial potential benefits to the states and the nation.

The Public Role in EOR Research

The situation I have just described is a classic case requiring publicly supported research. Major public benefits, with generalized and substantially delayed private benefits, are at stake. Generation of needed fundamental knowledge and understanding can stimulate market processes to realize these benefits.

The states, industry, and the Administration seem to agree with me. In its annual meeting last December, the Interstate Oil Compact Commission, representing all the producing states, made several recommendations to encourage EOR, including:

> A more concerted effort should be made to increase state and federal funding for enhanced oil recovery research.

The National Petroleum Council, industry's official advisor to DOE, also recommended increased EOR research:

> Industry in conjunction with universities and government must ensure that the necessary effort is put forth to

> develop the required technologies that will enable the recovery of the large volume of hydrocarbons discussed in this [EOR] report. Support of university research programs, by both industry and government, should be encouraged.

The Administration has recommended a small budget increase for EOR research while requests for nearly every other Fossil Energy program have been considerably reduced.

I believe that the DOE Fossil Energy program in enhanced recovery research can play a much needed role, along with efforts by industry and the states. The field management of this federal research program is in my own state. As State Geologist and member of the faculty of a leading energy-research institution, I closely follow developments in this program. Within its limited budgets, this program addresses the central unknowns of both the resource and its recovery technologies.

Two directions are being pursued in the current federal program to understand the resource better. The first is to improve the ability to measure, interpret, and characterize residual oil in the reservoir. This instrumentation and interpretation research is prerequisite to the understanding of specific reservoirs. Its priorities are a measurement of residual oil saturation and the effects of reservoir heterogeneities on fluid flow. The second direction is the maintenance and enhancement of the data bases and models that the program developed in cooperation with the National Petroleum Council. These analytical capabilities permit the program to assess the relative importance to the nation of specific R&D opportunities on the basis of overall contributions to domestic reserves and production. Thus, it lies at the heart of the program's logic and strategy. These capabilities have an additional, "spin-off" benefit that we have seen here today. As shown in the IOCC analysis presented earlier, they can be used to assist the states more fully to understand their opportunities in EOR. This federal-state cooperation is vital in helping the states determine what they can do to encourage EOR research and applications.

To better the understanding of EOR technologies, the program conducts fundamental research into all three of the major EOR techniques -- thermal, gas, and chemical flooding. Further, it conducts very long range research in novel, advanced EOR technologies, which has the use of micro-organisms to improve oil recovery as its current priority.

Thus, the program directly addresses the major scientific uncertainties that constrain the wide scale application of EOR. This very fundamental, long-term research is not the sort that industry can afford to undertake. It provides a common base of understanding so that the problems of poor predictability and unacceptable risks can be solved. This common base of understanding provides a foundation on which industrial and commercial research can build the technology to solve specific problems of particular reservoirs -- and get back in the oil-production business.

Recommendation

From all this, it is clear that I believe federal research in enhanced oil recovery has many concrete benefits to the producing states and to the nation as a whole. The EOR potential we have identified is large and the resource is massive. On this basis alone, I could readily justify a recommendation for funding several times larger than has been proposed. Higher funding rates would accelerate the program and increase its odds of success.

Simply stated, the nation's oil problem is our most critical energy problem. Oil provides 43% of our energy needs and is not replaceable in most of its present uses, especially as energy prices have fallen. EOR research is a direct, concrete step in ameliorating the problem of inadequate domestic production. The Administration's requested budget for EOR is only 4.4% of the total Fossil Energy request -- and only 0.3% of non-defense DOE research and development proposal. While I do not suggest that I am familiar with all of these programs, I find it difficult to understand this priority. At $10.6 million (plus $1.4 million for tar sands), the EOR research program is significantly undersized, even in a year of fiscal austerity.

Certain research projects that low budgets have minimized are among the most important areas for increasing understanding to benefit the producing states and the nation. Improved instrumentation and interpretation of reservoir properties is critical, but its funding is minimal. The data base and models developed out of the NPC study are a solid foundation, but significant improvements are needed to produce more refined analyses and assessments, especially at the state level. Basic EOR process research covers all the bases but so thinly as to endanger the odds of success. Research at universities has had to be funded at levels that seldom can sustain the "critical mass" of faculty and graduate students needed for a program of research as opposed to a series of small projects (few university grants or contracts exceed one person-year of effort). The respective states face substantially different research problems because their reservoirs are different, but little research is directed to state-specific problems. Finally, the evaluation of completed EOR field tests, which could teach us the most, have been reduced to mere paper studies, where detailed, empirical approaches are needed.

However, we are all mindful of the federal budget situation and the requirements for austerity. On this basis, I can describe the Administration's request -- $10.6 million (plus $1.4 million for tar sands) -- as adequate. But just barely.

The predecessors of this subcommittee, however, have tended to recommend reduction from the Administration request for EOR research funding while recommending substantially higher budgets for other Fossil Energy technologies. In some recent years, the resulting program was so small that little scientific progress could be made. This must not be permitted to happen again. To reiterate, the Administration request is just barely adequate to permit reasonable progress. It must not be reduced.

We are in a struggle against time. Currently, ignorance is winning as evidenced by the continuing decline in Lower-48 production. Liquid fuels supply almost all the energy requirements for the transportation sector of our economy; requirements that cannot be met in a timely manner by any alternative fuels. Without enhanced oil recovery, the nation will have no choice but to turn to ever increasing amounts of imports to satisfy liquid fuel demands. With enhanced recovery, however, we have a compelling option that affects national security, the trade and fiscal deficits, domestic productivity, and the producing state economies.

I urge you to consider the importance of oil to this country and the real potential for enhanced oil recovery. In this consideration, I am sure you and I will come to similar conclusions: enhanced oil recovery is too important to be left to chance. We must increase EOR research funding to a level that really helps America stay in the oil producing business and the states to remain economically healthy.

Statement by Dr. J. Read Holland, Director

The School of Mines and Energy Development

The University of Alabama

Before the House Science and Technology

Subcommittee on Energy Development and Applications

Hearings on Fiscal Year 1986 Authorization for the

Department of Energy's Fossil Energy Programs

March 11, 1985

This testimony pertains to FY 1986 Department of Energy non-nuclear R&D appropriations. The University of Alabama strongly endorses the continuation of specific research on Eastern oil shale at a funding level of at least $9 million in FY 1986.

Mr. Chairman and Members of the Subcomittee:

My name is J. Read Holland. I am Director of the School of Mines and Energy Development (SOMED) at The University of Alabama. The School of Mines and Energy Development conducts and supports mineral and energy related research which responds to state, regional and national needs. SOMED also supports the University's strong commitment to education and training by providing an opportunity for graduate and undergraduate level students to participate in a broad range of research projects underway in the mineral sciences.

During the past five years the University of Alabama has conducted research on processing of the Devonian-Mississippian oil shales that underlie much of the Central and Eastern United States to develop technology specifically tailored to improving processing characteristics of the shale. The research program has included the application of physical beneficiation, chemical extraction, and retorting technologies for obtaining maximum energy recovery, as oil or gas, from the shale. Early in the investigations the Mineral Resources Institute (MRI) at the University made a major breakthrough in upgrading the shales by physical beneficiation. First reports of the results of that research were reported in several papers presented at the 1981 Eastern Oil Shale Symposium in Lexington, Kentucky. MRI now is recognized as a leader in the beneficiation of Eastern oil shale.

This subcomittee was a key factor in the establishment of a federal Eastern oil shale research program for FY 1985 in the amount of $3 million for specific Eastern oil shale research in such areas as expanding the data base, increasing the utilization of fines, for moving bed hydroretorting, to study beneficiation, chemical composition of kerogen, primary and secondary reaction products of Eastern oil shale retorting, and for the gasification characterization of Eastern oil shale. That program now is being implemented by DOE, and it is our view that its continuation in FY 1986 will provide additional information needed to develop the Eastern shales into a viable national energy resource.

The marine oil shales of the East-Central U.S. potentially represent a larger, a more cost-effective, and a more attractive near-term energy resource than is commonly recognized. U. S. Geological Survey estimates are that the total "known resources" of the Devonian oil shales contain at least 400 billion barrels of oil, and that "probable extensions of known resources" contain an additional 2,600 billion barrels. These estimates are based on the use of a pyrolysis (direct heating) approach adopted for recovering shale oil from Western shales, but the approach is not particularly effective with the Eastern shales. Organic carbon levels in Eastern and Western shales are basically of the same magnitude but largely because of a low hydrogen to carbon ratio in the Eastern shales, the conversion of their organic carbon to oil by conventional pyrolysis is about 35% compared to 80% for the Western shales.

The beneficiation technology developed by our engineers for the Eastern shales recovers upgraded products that give oil yields similar to those from the Western shales. The raw Eastern shales are ground to an ultra fine size to liberate the oil fraction (kerogen) from the inorganic constitutents of the shale and then processed by froth flotation to recover concentrates with kerogen contents 2 to 2.5 times higher than those of the raw shale. The beneficial effects of pressurized hydrogen in a moving bed of oil shale (hydroretorting), rather than simple pyrolysis, improves the yield by an additional factor of two or more. Combination of the two approaches is synergistic and provides a striking improvement. This is illustrated by the following laboratory scale results obtained on a typical Eastern shale in cooperative research by The University of Alabama and HYCRUDE Corporation:

Feedstock/Recovery Method	Oil Yield (Gal/T)
• Raw shale/Pyrolysis	12
• Flotation concentrate/Pyrolysis	27
• Flotation concentrate/Hydroretorting	54

The joint University of Alabama-HYCRUDE research is only one example of the progress being made in developing an advanced technology tailored to processing the Eastern shales. Other avenues of research that are equally as attractive and may contribute to further development of our extensive Eastern shale resource also are deserving of continued funding support.

There are other factors that should be considered in supporting activities directed toward development of Eastern oil shales. In whatever manner the shales are processed, there will be a demand for substantial volumes of water for mining, processing, waste disposal, land reclamation, municipal growth, and power generation. According to a summary of a report entitled, An Assessment of Oil Shale Technologies, prepared by the Congressional Office of Technology Assessment, about 3.6 barrels of water will be consumed per barrel of product oil recovered during processing of oil shale. The establishment of an Eastern oil shale industry producing 1 million barrels per day of oil, or almost 25% of our current petroleum imports, will require about 150 million gallons of water daily. Data from U.S. Geological Survey Water Supply - Paper 2250, National Water Summary 1983 - Hydrological Events and Issues, indicate that the consumptive use of water in the East-Central region is only about 2% of the renewable water supply. Compared to the total water consumed for other uses, oil shale processing will increase the water demand only incrementally. Thus, the figures strongly suggest an availability of enough surface water in the region to establish a 1 million barrel per day oil shale industry, although some new reservoirs and pipelines within the area might have to be constructed to provide adequate water to the plants during seasonal low supply periods. The dispersal of oil shale operations throughout several states in the region with each operation producing perhaps 100,000 barrels of oil per day also would minimize the impact on local water consumption supplies.

In addition to water availability, other geographic features enhance the attractiveness of continued efforts to develop the commercial potential of the Eastern black shales. These are:

- The major shale resources occur in the populated industrial heart of the nation where an adequate, diversified supply of labor is available and a convenient end-use market is also available for the shale oil and oil-derived hydrocarbon liquids and gases produced.

- The Eastern oil shale region has an infrastructure consisting of oil refineries connected by pipeline, rail and waterway distributionsystems extending throughout the Eastern United States. This system today handles a substantial volume of the liquid hydrocarbon fuel needs of the nation, and it will be available for handling and processing shale oil and downstream products.

- The Eastern shales are generally amenable to surface mining. Surface mining is low cost and favors high recoveries of the economic mineral from the deposit. Proper reclamation of the strip mined land is an urgent factor that must be dealt with but it should be less of a problem in the Eastern United States than in other parts of the nation. The humid, temperate climate of the region should favor revegetation of the land within three to five years following any mining activity.

- A positive incentive to utilizing Eastern oil shale is the attitude of the people toward natural resources development. The populace understands surface coal mining and is aware of mined land restoration measures now being practiced. The people would be likely to accept oil shale mining with the same generally supportive attitude they have toward coal mining.

A relatively large number of states will benefit from the development of a successful approach for producing oil from Eastern shale, and indirectly the entire nation will benefit. The more extensive Devonian deposits are located in Alabama, Indiana, Kentucky, Michigan, Ohio and Tennessee. In addition, substantial deposits of oil shale occur in Illinois, New York, Pennsylvania, Virginia and West Virginia. Full development of the oil shale resources in these states can make a substantial contribution to meeting a significant part of our petroleum consumption requirements for centuries to come. Furthermore, any technology that is developed for processing the oil shales from these states should also be applicable to extracting the oil from the low grade oil shales occurring in other states such as Alaska, Montana, Nevada and Oklahoma. Thus the benefits are by no means confined to the Eastern United States.

The University of Alabama strongly supports the Eastern oil shale shale R&D program initiated in FY 1985, and urges the appropriation of a rather modest $9 million budget for its continuation in FY 1986. This level of funding will support the investigation and further development of a number of promising technologies. The research efforts we consider important and worthy of funding are as follows:

- Upscale beneficiation and moving bed hydroretorting techniques including process integration and economic evaluation of oil production from Eastern shales.

- Study environmental aspects of beneficiation and hydroretorting to minimize potential adverse environmental impacts of processing the shale, with emphasis on sulfur removal.

- Expand Eastern oil shale resource data development and determine the availability of known reserves and resources through establishment of an oil shale sample bank and data base.

- The Eastern oil shales also should be characterized with regard to the physical and chemical properties of the kerogen and associated minerals, the composition and structural relationships of the carbonaceous phases present in the shales, and the accumulation of other data affecting the mechanisms and kinetics of retorting and hydroretorting, and oil and gas yields.

- Develop new or advanced grinding, extraction and agglomeration techniques for Eastern oil shale processing.

- Establish technology for recovery of accessory minerals and trace metals from oil shale processing products and wastes to augument our mineral resource base.

Thank you for this opportunity to share my views with you today. I will be pleased to address any questions that you may have.

TENNESSEE TECH
UNIVERSITY
Tennessee Technological University
Associate Vice President for Research
Box 5012 • Cookeville TN 38505 • 615-528-3374

March 8, 1985

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development
and Applications
House Science and Technology Committee
B-374 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

I have enclosed a statement for the record regarding the continuation of the eastern oil shale R&D program which was established for fiscal year 1985.

In 1980-81 several faculty members at Tennessee Tech conducted a preliminary feasibility study on converting Chattanooga Oil Shale (an eastern oil shale deposit) to synthetic liquid fuel. This study concluded that eastern oil shale is a significant domestic energy resource. It is extremely important, therefore, to continue environmental and process research relating to both demonstrated and promising eastern shale retorting technologies so that the full utilization of this resource can be achieved.

The location of the eastern oil shale deposits offers the advantages of available work force for mining and processing, oil refining capacity within close proximity, and oil distribution networks and markets nearby. These advantages will lead to the ultimate development of the resource. Research performed now will ensure that the most efficient processing techniques and environmental control technologies will be utilized.

If you have any questions regarding the testimony, please contact me at the above address or telephone number (615) 528-3374.

Sincerely yours,

W A Goodwin

W. A. Goodwin
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Enclosure

Statement

by

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Submitted for the Record

to the

House Science and Technology Committee
Subcommittee on Energy Development and Applications

March 8, 1985

This testimony is addressed to the Department of Energy's non-nuclear R&D appropriations for fiscal year 1986. Tennessee Technological University supports a $9.0 million program for eastern oil shale R&D consisting of $3.0 million for fundamental research activities, $4.0 million for advanced research activities, and $2.0 million for environmental studies.

Mr. Chairman and Members of the Subcommittee:

My name is W. A. Goodwin. I am Associate Vice President for Research, Office of Research, Tennessee Technological University.

Last year, your subcommittee took part in the establishment of an eastern oil shale R&D program. I would like to express our appreciation for this action and at the same time take this opportunity to point out the benefits of the continuation of this program.

The oil shale of the eastern United States is a large resource which offers significant potential for the production of synthetic fuels. Although the oil shale of the western U.S. typically yields more oil than its eastern counterpart, much progress has been made in the development of processes for specific eastern shale which will increase the yield of oil from these shales. The location of eastern oil shale offers many advantages. Much of the resource is surface mineable, it is close to areas populated by the skilled workforce necessary for mining and processing of oil shale, and it is close to refineries, distribution networks and markets.

The improvements obtained by eastern shale process research, coupled with the advantage of its location, ensure that at some point in the future, eastern shale will be developed as a major domestic source of synthetic liquid fuels. Because this resource is non-renewable, it is vital to develop the most efficient processes for full utilization of the eastern shale resource. This approach has environmental as well as economic benefits. The extraction of more oil per ton of rock means that less land will be disturbed per unit of oil production capacity.

It is necessary to maintain a program to research new technologies which will more fully utilize the eastern oil shale resource and to support continuing research on technologies which have demonstrated efficient utilization of eastern oil shale. In that regard, we recommend a funding level for FY 1986 of $3.0 million for continuation of fundamental research efforts and $4.0 million for advanced research efforts.

We also recommend a funding level for fiscal year 1986 of $2.0 million for environmental studies. Studies must be performed now to ensure that environmental control technologies keep pace with the development of various processes. It is also necessary to gather the necessary baseline environmental data for the eastern U.S. including existing sources of air pollution and the probable effect of an oil shale retorting industry on air quality, the seasonable availability of process water for the requirements of a mature oil shale industry, and the best procedure for land reclamation at mining sites.

It is especially desirable to have the baseline environmental studies performed by local institutions which do not stand to profit by the development of an oil shale industry. Results of the environmental studies can help to guide process developers in their attempts to evaluate economic trade-offs between various process design alternatives which have different impacts on the environment.

Thank you for the opportunity to present my views on the necessity of an eastern oil shale R&D program for FY 1986.

TENNESSEE TECHNOLOGICAL UNIVERSITY

PROGRAM FACT SHEET--EASTERN OIL SHALE

R&D Recommendation for FY 1986

FUNDAMENTAL RESEARCH

Fundamental research projects should be conducted to ensure the continued entry of new technologies for processing of eastern oil shale.

Eastern and western oil shales are significantly different, both geologically and chemically. Eastern shales can be processed by the standard thermal retorting technologies utilized for western oil shale, however the resulting yields are considerably lower than for western shales. Techniques such as moving-bed hydroretorting have demonstrated much higher yields for eastern shale, and other techniques such as oil shale beneficiation, solvent extraction and fast heatup, fluidized bed thermal retorting have also shown promising results. Fundamental research in these and other new technology ideas will result in further improvement of eastern shale retorting technologies.

TTU suggests a funding level of $3.0 million for eastern oil shale fundamental research activities in FY 1986.

ADVANCED RESEARCH

Advanced research projects on technologies which have been demonstrated to efficiently utilize the eastern oil resource are recommended. These projects will provide detailed data for environmental studies such as emissions of sulfur and nitrogen oxides, the amount of process water required and contaminants which may be present in the water, leachates present in processed shale, and trace element distribution in solid, liquid and gaseous products of retorting.

TTU suggests a funding level of $4.0 million for advanced eastern oil shale research activities in FY 1986.

ENVIRONMENTAL STUDIES

Environmental studies must be conducted utilizing the process data obtained in the fundamental and advanced research projects. It is important to ensure that the development of environmental control technologies keeps pace with the process technologies.

Significant work remains to be done regarding the seasonal availability of water, the impact on air and water quality, and spent shale disposal. These environmental considerations are both process and site specific. Most of the work of this nature which has been performed on western oil shale is not directly applicable to the eastern shale situation.

TTU recommends a $2.0 million funding level for environmental studies.

Statement of Bernard S. Lee, President
Institute of Gas Technology
Before the House Committee on Science and Technology
Subcommittee on Energy Development and Applications
Hearings on FY 1986 Authorization for the Department of Energy's
Fossil Energy Research and Development Program

March 14, 1985

Mr. Chairman and Members of the Subcommittee:

My name is Bernard S. Lee. I am President of IGT, a not-for-profit energy R&D organization in Chicago.

The 99th Congress faces the difficult task in the coming year of making decisions which lead to cutting the Federal budget deficit. While undertaking this challenge, the Congress should recognize the need for high-quality technological development that will enable us to achieve a state of energy readiness and security.

Some people believe that an economic trend which will contribute to the nation's energy well-being is the "deindustrialization" of America, characterized by the growing importance of the service-producing sector at the expense of goods-producing industries. In this vision, the old energy-intensive basic "smokestack industries" will vanish as we become a nation of computer technology and information suppliers, leaving the smokestack industries to our import partners. It is tempting to attribute the decline in energy consumption of recent years to more or less irreversible structural changes in Western economies and to assume that future economic growth will be realized with ever-diminishing energy inputs. Against the background of the worldwide glut of conventional energy sources at declining prices, this line of reasoning dictates that little money and effort should be spent on the development of new energy sources or the technology to use energy more efficiently.

But already there are warning signs that the past few years have been only a reprieve from our energy problems, not a commutation of sentence. Oil and gas resources have not increased and demand has begun to rise. Estimates for 1984 indicate that for the first time since 1979, demand for petroleum products rose 3% over the previous year. Net petroleum imports, which had fallen for four years in a row, grew 9% last year.

Furthermore, OPEC's recent price reduction will almost certainly not be the last, which means that consumption will continue to rise. The Department of Energy's most recent forecast projects a 20% increase in U.S. petroleum consumption between 1983 and 1995. DOE also foresees an even sharper 70% jump in oil imports to an all-time high of nearly 9 million bbl/day by 1995 as domestic petroleum production continues its slow but inexorable decline. An interruption of supplies followed by soaring prices could find the U.S. and the West back where they were ten years ago. The practical value of the Strategic Petroleum Reserve is unknown, and the U.S. still has no concrete plan for how and when to use it.

In addition, the demise of the goods-producing sector has been greatly exaggerated. This sector, especially its durable goods component, has historically borne the brunt of economic downturns, and conversely, has grown rapidly during periods of expansion. In the two years following the recessionary trough of November 1982, for instance, real economic growth in the durable goods subsector was 8.3/year — more than double the 4.0% annual growth rate reported for the service sector.

DOE is now predicting that energy use in the industrial sector will grow faster than in any other sector as growth in output outstrips the energy efficiency gains made in the recent past. For example, the 4.2% growth in output projected for the commercial sector over the next five years will be exceeded in many energy intensive-industries, including chemicals where a 5.6% increase in output is forecast and basic metals, a 4.7% gain. Thus, we can conclude that many of the changes we have experienced in our economy and our energy use patterns over the past few years were more cyclic than structural.

Against this background of uncertainty and change, the U.S. does not have an ultimate plan to provide future energy supplies. Rather than debate whether we should regulate or deregulate the energy industries, we suggest a policy based on strong support of research and technology development. This policy should be broad enough to encompass many eventualities and leave plenty of room for changes of direction; in short, place the United States in a state of readiness. Restricting the government's role in funding R&D to cases of potential high risk and high payoff and to basic research severely limits the available options. Energy research is mainly applied research and should be supported through the entire chain of development from basic research to commercial applications, including the crucial process development and commercial demonstration steps.

American leadership in world technology has already begun to erode. Ten years ago, the U.S., with 5% of the world's population, generated about 70% of the world's new technology. Today, we only generate about 50%. Our comparative record with respect to energy research and development is even more dismal. In both 1979 and 1980, the U.S. led the other countries that belong to the International Energy Agency in the ratio of its government research, development and demonstration expenditures to Gross Domestic Product. By 1983, this ratio slipped from 0.07% from 0.16% in 1979, and the U.S. was only ninth among the 19 IEA countries. In particular, our oil and gas R&D spending was only $38 million in 1983, much less than the $105 million in Canada and $89 million in Japan. New energy sources, including solar and biomass, dropped from 16% to 10% of our government energy R&D funding. Coal R&D spending plummeted from 19% in 1980 to around 9% in 1983. The share of nuclear R&D, by comparison, rose from 39% to 69% over the same period. Coal is our nation's largest energy resource. With demand for coal projected to rise and environmental concerns mounting, assigning such a low priority to develop and improve technologies for the cleaner utilization of coal seems totally illogical.

There is generally a mismatch between our future energy supply requirements and government-supported R&D. Private industry looks for short-term payoff in its investments; therefore, financial support by industry of energy research in the long-term public interest is not always feasible. And yet, our nation's future prosperity depends on the existence of technologies which will provide secure sources of energy. The necessary technology will not be available if government support is not forthcoming for energy R&D.

For FY'86, I fully support the gas industry recommendations of $200 million for gas-related R&D, plus $2 million for thermal energy storage. The following are specific R&D programs in which IGT is actively engaged. and Attachment 1 describes these in more detail.

Surface Coal Gasification

IGT recommends $1 million to operate the Advanced Multipurpose Research Reactor to examine coal-ash particle dynamics in fluidized-bed jets and cyclones, and $1 million to test a novel two-step bioprocessing technique for removing sulfur while simultaneously methanating coal gas. IGT also recommends $3 million to operate the high-pressure 8" diameter ash agglomerating PRU gasifier to extend the ash agglomerating gasification technology to the 500-psi range, $2 million to test pollutant recycle gasification as a means of eliminating sulfur and organic pollutants normally produced in coal gasification plants, and $2 million to test novel devices for eliminating particulate dust from hot product gas streams.

Fuel Cells

IGT recommends $3 million to develop a contaminant-resistant molten-carbonate fuel cell capable of processing gases containing sulfur and chlorine.

Unconventional Natural Gas

IGT recommends $1 million to continue operation of CORAL and the development of ExTRA for obtaining high resolution steady-state measurements of gas and liquid permeability of Devonian shale, tight sandstone, and coal seams.

Geopressured Resources

IGT recommends $1 million to develop improved laboratory test procedures and field instrumentation capabilities on existing test wells to provide the reference data base necessary to establish reliable predictive correlations between laboratory measurements and actual well production.

Eastern Oil Shale Gasification

IGT recommends $1 million to conduct fluidized-bed spent shale agglomerating gasification tests with Eastern shale.

Conservation

IGT recommends $2 million to develop the Hyperabsorption cycle heat pump, $2 million to develop a new thermochemical recuperator system (TCR) for high temperature heat recovery, and $2 million to extend the cyclonic combuster technique to develop a highly efficient gas fired boiler.

Biomass

IGT recommends $1.5 million to develop a high-pressure biomass feed system for wood gasification, initiate studies on integrating fuel cells with the gasification system, and test product gas recycle in the RENUGAS PRU. IGT also recommends $0.5 million to assess the biological constituents of a novel culture to enhance the yield of methane and other chemicals by direct digestion of unpretreated short rotation woody biomass crops.

LNG Safety

IGT recommends $0.5 million to complete an LNG storage tank safety model by obtaining data at an existing, instrumented LNG storage tank.

Thermal and Mechanical Energy Storage

IGT recommends $2 million to continue to develop composite thermal energy storage (TES) media system by obtaining data at the PRU level.

Thank you for the opportunity to present my views. I will be happy to answer your questions.

ATTACHMENT 1

Selected Energy Research Recommendations FY'86
Program Fact Sheet

SURFACE COAL GASIFICATION

Advanced Multipurpose Fluidized Bed Research Reactor

The fluidized bed is rapidly becoming the most desirable method for coal gasification. Unlike entrained beds, which operate above 3000°F, the fluidized bed achieves high coal conversion at temperatures below 2000°F. Therefore, the exotic materials needed to operate at extreme temperatures are avoided and there is no need for an inefficient water quench to cool the raw product gas to below 2000°F for subsequent heat recovery. Unlike moving bed gasifiers, tar production is eliminated because tars are gasified within the fluidized bed.

Future development and scale-up of the fluidized-bed technology requires development of a reliable data base at elevated pressures and temperatures. Also, a firm understanding of the fundamental behavior of coal and ash particles in the fluidized bed and their interaction with fluidizing gas jets, other particles, and/or mechanical devices (such as cyclones) needs to be established. Penetration of the steam-oxygen jet into the bed, particle ingestion by the jet, and the resultant concentration and temperature profiles within the jet must be defined before reliable scale-up methods can be established for high-pressure fluidized beds.

- IGT recommends $1 million for the operation of an existing high-temperature, high-pressure advanced multipurpose research reactor (AMRR) to obtain fundamental data on fluidized-bed temperature profiles and on coal and ash particle behavior in fluidized-bed jets and cyclones.

Advanced Microbial Upgrading of Coal-Derived Gas

IGT has been actively testing the use of anaerobic bacteria to clean and upgrade raw gasifier product gas. Experiments to date have identified and isolated bacteria that can remove hydrogen sulfide from the gas and convert the sulfide to free sulfur. Anaerobic bacteria have also been separately tested to convert coal-derived gas to methane, thereby increasing the heating value of the product gas. Similar bacteria might be used to clean the tars and oils present in coal-derived gas.

Bench-scale tests are needed to integrate the sulfur removal and methanation bioprocessing steps, evaluate the effects of tars and oils, and determine the operating conditions needed to upgrade raw gasifier product gas to sulfur-free, high quality fuel gas.

- IGT recommends $1 million to test the synergistic effects of integrating a two-step bioprocessing technique for removing sulfur while simultaneously upgrading coal-derived gas.

Continued Testing of the High Pressure Ash Agglomerating 8-inch Diameter PRU

An ash-agglomerating gasifier can process all types of coal — including low quality, high ash, run-of-mine coal — without producing undesirable by-product tars or discarding the fines produced in the coal mining and sizing operations. These technical advantages can significantly reduce the cost of coal gasification because more than 95% of any type of coal can be converted into high quality, multipurpose product gas. This technology, now successfully demonstrated at low pressure, should be extended to the 500-psi pressure range needed for the production of SNG, combined cycle power, medium-Btu fuel gas, and chemical synthesis gas. Further operation of the 8-inch diameter Process Research Unit (PRU) is required to obtain data on the simultaneous effects of pressure and temperature on coal conversion, gas quality, environmental characterization, and the ash separation technique.

Adding dolomite to the PRU removes hydrogen sulfide from the product gas and eliminates the need for cooling to remove hydrogen sulfide by conventional techniques. The sulfated dolomite can be removed with the agglomerates and either processed for recycle or discarded with the ash. Detailed operating data are needed on the optimum conditions for incorporating this direct desulfurization technique into the ash agglomerating gasifier process.

- IGT recommends $3 million to continue operations of the high pressure, 8-inch diameter PRU to optimize the direct desulfurization technique and extend the ash agglomerating gasifier technology to the 500-psi pressure range needed for broad commercial applications.

Recycle Gasification of Coal Gasification Pollutants

Environmental control is a major cost factor in coal gasification plants. Current technology to remove pollutants from the effluent streams of the sulfur plant and the sour water stripper requires major process equipment installations. Significant reductions in the capital and operating costs of coal gasification facilities can be realized if these equipment installations can be eliminated by recycle gasification. For example, tests have shown that tars produced by some gasifiers can be recycled and gasified. If pollutants from the sulfur plant and sour water stripper can be similarly recycled and eliminated, coal gasification plants could be greatly simplified and the resultant cost of gas significantly reduced.

- IGT recommends $2 million to experimentally test pollutant recycle gasification to eliminate sulfur and organic pollutants normally produced in coal gasification processes.

Particulate Dust Removal

Cyclones are usually used to remove most of the particulate dust from coal gasifiers. But the residual dust content is still too high to allow the gas to be used in turbines or processed in other downstream equipment. Cyclones, although simple to operate, are inherently limited to a very narrow range of operation. They sometimes overload and erratically discharge large amounts of particles into downstream equipment and, therefore, require a fail-safe backup device. IGT has tested such a backup device, a novel ceramic filter, and found essentially complete removal of dust that escapes a typical cyclone.

However, because these filters must be operated cyclically to allow for filter cleaning, cycle time is an important factor in the life and cost of the filter. In addition, IGT has also shown that in-bed baffles can be used to reduce the amount of dust entrained from the bed. Such baffles offer great promise of decreasing the dust load on the cyclone and hence, the amount of dust that must be removed by the filter, thereby greatly increasing the cycle time and the life of the ceramic filter. Data on the system of in-bed baffles, cyclones, and ceramic filters are needed at the PDU level of operation to evaluate their performance on dust removal from hot coal gas.

- IGT recommends $2 million to modify an existing PDU coal gasifier and test the total dust removal system of in-bed baffles, cyclones and a novel ceramic filter to produce gas suitable for use in turbines and other downstream process equipment.

CONTAMINANT RESISTANT MOLTEN CARBONATE FUEL CELL

Molten carbonate fuel cells show significant performance degradation when exposed to contaminants, such as sulfur and chlorine in the feed gas. Since it is complex and expensive to remove all such contaminants from a coal-derived feed gas, a contaminant-resistant molten carbonate fuel cell would maintain a high level of performance while simultaneously decreasing the complexity and cost of the feed gas cleanup process. The optimum coal gasifier/molten carbonate fuel cell combination minimizes cleanup of the coal gas, maximizes contaminant resistance of the fuel cell, and withstands occasional unexpected gasifier upsets without permanent damage to the cell. In developing such a contaminant-resistant fuel cell system, IGT has determined and correlated the effects of some of these contaminants, such as hydrogen sulfide, on cell behavior and has accumulated sufficient data to begin design and testing of different proof-of-concept configurations. Some of these designs, such as the membrane barrier, could also solve other molten carbonate fuel cell problems such as anode creep, carbonate management and corrosion.

- IGT recommends $3 million to develop a contaminant-resistant molten carbonate fuel cell and determine the most efficient and cost effective coal gasifier/molten carbonate fuel cell combination.

UNCONVENTIONAL NATURAL GAS

Current analytical models for predicting the recovery of gas from most unconventional gas media assume that only the gas moves within the rock. Previous laboratory and field work have indicated that this assumption is not true for Devonian shales and coal seams and is often not true for tight gas sands. Data from IGT's high resolution, steady state computer-operated rock analysis laboratory (CORAL) show that the presence of even small amounts of liquid, either water or oil, significantly affects the flow of gas.

CORAL accurately measures rock properties for gas flow in the absence of liquid, but can not measure the simultaneous flow of gas and liquid. IGT has begun to develop a new test apparatus, the Experimental Tight Rock Analysis (ExTRA) facility, in which rock properties, such as permeability and porosity, would be measured while both gas and liquid move within the rock. The addition of high resolution co-permeability data to that already being obtained with CORAL will provide the range of data essential to the development of reliable flow models that can accurately predict gas production for Devonian shale, tight sandstone and unmineable and interbedded coal seams.

- IGT recommends $1 million to continue operation of CORAL and the development of ExTRA for obtaining high resolution, steady state measurements of gas and liquid permeability for Devonian shale, tight sandstone, and coal seams.

GEOPRESSURED RESOURCES

The economics of gas production from hydropressured and geopressured reservoirs that produce large quantities of brine are not favorable unless the hydrocarbons exceed their solubility at reservoir temperature and pressure. The technique of measuring very small changes in hydrocarbon content with continued brine production can be used to predict subsequent gas production. However, instrumentation currently being used at the well head cannot accurately measure these changes or whether the hydrocarbons exeed they solubility. Existing methods of measuring hydrocarbon solubility both at the well head and in the lab must be upgraded if this technique is to be successfully developed. New instrumentation is needed at the well head to digitally record all raw data and new sampling devices are needed to accurately deduce bottomhole pressure and saturation levels. Also, new laboratory apparatus and test methods are needed to establish accurate data on hydrocarbon solubility at typical bottomhole conditions.

- IGT recommends $1 million to develop improved laboratory test procedures and field instrumentation capabilities on existing test wells to provide the reference data base necessary to establish reliable predictive correlations between laboratory measurements and actual well production.

EASTERN OIL SHALE GASIFICATION

Eastern Devonian oil shales are a significant energy resource for the United States. The total potential of this resource in the six states of Indiana, Kentucky, Ohio, Tennessee, Michigan and Alabama are estimated to be over 2300 quads. Compared to coal, these shales contain more mineral matter and thus have lower energy content per ton. However, the deposits of this resource are often 10 times thicker than those of bituminous coal. Also, these deposits usually have less than one-tenth the over-burden of typical Eastern coal deposits. Because of these geological factors, Devonian shales can be mined at less cost than coal per unit of energy mined. However a significant amount of fines are produced in mining and economic shale processing system must fully utilize the energy contained in these fines. This can be achieved by fluidized-bed gasification to produce a medium-Btu gas that can be used directly or upgraded to SNG. This process accepts fines and when operated in the agglomerating mode, is highly efficient and can produce a non-leachable residue. Beneficiation of the shale prior to gasification increases its carbon content and further improves gasification efficiency.

- IGT recommends $1 million to operate existing shale-ash-agglomerating fluidized-bed gasification equipment with beneficiated Eastern oil shales and shale fines.

CONSERVATION

Hyperabsorption-Cycle Heat Pump

The conventional absorption system, which has been commercialized for almost 40 years, has played a significant role in the current development of residential gas-fired, absorption-type heat pump applications. In the conventional system, the energy for vaporization is supplied by an external source such as the combustion of natural gas. The major limitation of the conventional system is its relatively low efficiency.

IGT has been developing a novel, high-efficiency cycle, called the Hyperabsorption Cycle, which uses saturated solutions of liquid, solid and vapor in equilibrium. In the new cycle, the heat liberated during crystallization significantly reduces the need for external energy; thus, fuel consumption is reduced and efficiency increased. The new cycle is closed and the solids formed during the crystallization step are transported to another part of the system where simultaneous solid dissolution and absorption cooling takes place. This cycle has the capability of being used in both residential and industrial applications. The design, construction, and operation of a proof-of-concept unit is needed to optimize the methods of solids crystallization, transport, and dissolution.

- IGT recommends $2 million to develop a new, high-efficiency, gas-fired hyperabsorption heat pump cycle.

Thermochemical Recuperator System (TCR)

Large quantities of high-temperature energy are currently discarded by U.S. industries because present equipment and practice can recover only a small part of this waste energy. IGT has conceived a new heat recovery system, termed the Thermochemical Recuperator (TCR) system, that can recover heat normally discarded from high-temperature industrial furnaces such as used in the glass and steel industries. This system absorbs high-temperature waste heat and uses it to transform natural gas into synthesis gas which is then used to reduce the fuel requirements of the furnace. Analysis indicates that the TCR is capable of recovering 80% of the waste energy in such flue gases at competitive costs. This is 50% better than current thermal methods of heat recovery. To obtain data on heat transfer, tube fouling, burner operation, and flame characteristics, it will be necessary to design, construct and operate a proof-of-concept TCR PDU of about 1.5 million Btu/hr. These data will be used for the detailed design of a commercial prototype.

- IGT recommends $2 million to develop a Thermochemical Recuperator (TCR) system through proof-of-concept.

High Intensity Cyclonic Fire-Tube Boiler

Fire-tube boilers, which range in size up to 50 million Btu/hr, are a major industrial energy consumer. The current installed capacity of such boilers is about 2 trillion Btu/hour in North America, with annual additions of about 200 billion Btu/hour. Typically, such boilers produce average NO_x emissions of about 100 parts per million (ppm). Emerging technology being developed to reduce these emissions can only be applied to boilers of less than 10 million Btu/hr. This corresponds to only about one-half of the total installed capacity of fire-tube boilers, representing about 40% of total emissions.

IGT has been developing an environmentally-preferred burner that can be applied to all fire-tube boilers regardless of size. Available data with this novel burner indicate that NO_x can be reduced to 20 ppm — a significant reduction, well below best current design practice for boilers. The burner is based on IGT's cyclonic combustion concept, which has demonstrated remarkable combustion stability. Because the novel burner is inherently scaleable, it is particularly applicable over the full size range of fire-tube boilers. Other advantages of this burner include dual fuel firing capacity, smaller and less expensive construction and the capability of raising high-pressure steam.

- IGT recommends $2 million to develop the cyclonic combustion technique for fire-tube boilers and conduct tests of 4 burners under actual process industrial conditions.

BIOMASS

High-Pressure Thermochemical Gasification

IGT has shown that its RENUGAS process can gasify woody biomass to produce a high quality fuel gas useful for SNG production, direct combustion, or combined cycle power generation such as feed to a fuel cell. The IGT RENUGAS PRU would be ideal for testing the operation of fuel cells with gas generated from various forms of biomass. The woody biomass currently enters the high-pressure gasifier through a lockhopper system which requires a separate pressurizing gas that decreases the potential efficiency of the system. A feeder that could eliminate the need for lockhopper pressurizing gases, such as an extrusion/plug feeder, would significantly increase system efficiency. Such a feeder also promises to increase the types and sizes of biomass fed to the gasifier. Another means of increasing system efficiency is to replace steam as the principal gasification agent for the biomass. This can be accomplished by recycling process-derived gas, such as carbon dioxide, to replace some or all of the process steam currently used for gasification. This could greatly reduce or eliminate the need for a high-pressure process boiler and reduce overall system costs.

- IGT recommends $1.5 million to develop a high-pressure biomass feed system, initiate studies on integrating fuel cells with the gasification system, and test product gas recycle in the RENUGAS PRU.

Biogasification or Wood

Short rotation woody biomass represents a potentially large, renewable feedstock for bioconversion to substitute natural gas. Until now, it has been necessary to chemically pretreat wood before microorganisms could convert it into methane. IGT has developed a mixed culture of bacteria that directly convert many of the wood components to methane and other chemicals without pretreatment. Laboratory studies to identify the organisms and the fundamentals of the metabolism are needed to define those factors leading to increased yields and decreased reactor size, thus ultimately improving process economics.

- IGT recommends $0.5 million to assess the biological constituents of a novel bacterial culture to enhance the yield of methane and other chemicals by direct digestion of unpretreated short rotation woody biomass crops.

LNG SAFETY

Improved Safety Model for Liquefied Natural Gas (LNG) Storage Tanks

Natural gas is often transported and stored in very large cyrogenic tanks. The dynamic interactions between the stored liquid, changing atmospheric conditions and operator control actions require further definition under a wide variety of actual operating conditions. Such data are necessary to model these interactions so that the effects of operator intervention can be reliably predicted over the entire range of operating situations met in practice. This work will produce guidelines for LNG storage tank operations and equipment specification that limit or prevent uncontrolled pressure changes and hydraulic instabilities in the LNG (rollover). The primary benefit of these guidelines is improved safety in oprations by reducing the liklihood of venting of spilling of LNG. The Liquefied Gaseous Spill Test Facility can be used to gather data and develop models describing the dispersion of vapor resulting from such spills. However, additional data and models are needed to improve the design and operation of large cryogenic tanks with the goal of minimizing the possibility of such spills.

The necessary data can be obtained from the operation of an existing instrumented LNG tank. The work involves data gathering, model development, model utilization, and guidelines testing. Verification of the model can be achieved by using the existing instrumentation at other LNG storage sites, such as the Liquefied Gaseous Spill Test Facility.

- IGT recommends $0.5 million for completion of the LNG storage tank safety model by obtaining data at an existing, instrumented, LNG storage tank.

THERMAL AND MECHANICAL ENERGY STORAGE

Direct Contact Composite Media TES System

There are many cyclic high-temperature industrial processes, such as kilns for ceramics or bricks, which discard heat during the cooling part of the cycle and, therefore, waste considerable high-temperature energy. If this energy could be stored at high temperature and used in the heating part of the next cycle, as much as 45% of the energy used in a typical kiln could be saved. Current high-temperature Thermal Energy Storage (TES) is accomplished by heating a ceramic brick during "charging" and cooling the brick to recover the heat during "discharging." Because of the low energy storage capacity of ceramic brick, this results in large, heavy heat storage systems. Increased energy storage capacity can be achieved using phase-change materials which would be alternately melted and frozen in the desired temperature range. The energy would be stored during melting and be released when the material solidifies. In all previous system designs, this has proven impractical because of the great resistance to heat flow through the solid material.

IGT has developed a composite media in which a salt with the desired melting temperature is contained within a porous ceramic. Because of the method used to fabricate this media, the composite TES system stores large amounts of heat while avoiding the heat transfer problems associated with the formation of solid salt. The composite media is designed so that the molten salt remains within the porous ceramic throughout the temperature cycle. When compared to ceramic bricks, the composite TES system results in 36% less weight, 58% less volume, and 37% less cost, at an increase of more than 25% in efficiency.

- IGT recommends $2 million to construct a PDU, conduct tests of the composite media thermal energy storage (TES) system, and use this PDU test data to initiate design of a cost-shared, proof-of-concept facility to be located at an industrial plant.

TESTIMONY BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
UNITED STATES HOUSE OF REPRESENTATIVES

11 March 1985

LaPorte Indirect Coal Liquefaction Process Development Unit and Supporting Research and Development

by

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LaPorte Indirect Coal Liquefaction
Process Development Unit and
Supporting Research and Development

Introduction

Good morning, Mr. Chairman and Members of the Subcommittee. I am George Roberts of Air Products and Chemicals, Inc. (Air Products). It is a pleasure to be with you today, and I appreciate the opportunity to testify at these hearings. My responsibilities at Air Products include both the development and commercialization of new technologies, one of which is an indirect coal liquefaction process called Liquid Phase Methanol (LPMEOH*), being developed jointly with the Department of Energy (DOE).

The purpose of my testimony today is to ask for continued financial support from the DOE for this LPMEOH project, which has the potential to become an important national- and world-scale innovation. Specifically, I request the committee to authorize an additional $6.7 million in the DOE's FY 1986 fossil energy budget, with these funds specifically earmarked for operation and support of the DOE Process Development Unit (PDU) at LaPorte, Texas. These funds will allow further development of new cost-effective technology for producing methanol from coal. However, in requesting this funding, I want to emphasize that the benefits of this research project will extend far beyond just methanol production. The project has already produced and will continue to produce important data that will benefit other indirect coal liquefaction technologies, including the Liquid Phase Fischer-Tropsch technology, simultaneously being developed with DOE support, to selectively produce diesel fuel from coal.

In support of this request for funding, it gives me great pleasure to be able to report to you on the actual progress of the research that is currently underway, the plans for which I discussed in previous testimonies to this subcommittee. Following this current status update, I will outline plans for additional research at LaPorte, and then outline plans for future commercial development of the LPMEOH technology.

Current Status

As part of DOE's plan for long-range research on indirect coal liquefaction, Air Products was contracted in September 1981 to design, construct, and operate a PDU to prove the feasibility of the LPMEOH process. Chem Systems Inc., the inventor of the process, was the key subcontractor. In addition, the Electric Power Research Institute (EPRI) and Fluor Engineers and Constructors, Inc. joined Air Products as private cost-sharing participants.

Under this contract, which concludes in June 1985, a PDU producing 5 tons of methanol per day was successfully commissioned and is being operated at Air Products' synthesis gas facility in LaPorte, Texas. Several LPMEOH process runs were conducted between March and June 1984. Let me describe these runs and summarize the major findings:

*A trademark of Chem Systems Inc.

- First, an 11-day shakedown run was conducted in March 1984 to demonstrate process operability under a variety of conditions. The run was successful in three ways:
  - The PDU operated over the complete design range of temperature, pressure, and flow, achieving a maximum methanol production rate of 8 tons per day (TPD).
  - First-of-a-kind hydrodynamic data vital to the design of the reactor, were obtained.
  - A 98% on-stream time was achieved; vital pieces of hardware performed reliably; and the PDU was found to be in good condition upon post-run disassembly and inspection.
- The second run was continuous for 40 days in April and May 1984. This test examined catalyst performance with CO-rich synthesis gas feed, typical of modern, advanced coal gasifiers. Results were as follows:
  - The PDU operated exceptionally smoothly; the on-stream time was 99.8%. Over 166 tons of methanol were produced.
  - Valuable information was obtained on methanol productivity and catalyst performance, including its lifetime and how its properties changed. The observed catalyst deactivation exceeded the rate experienced in earlier, laboratory-scale tests.
  - Again, the PDU was found to be in very good condition when it was opened for inspection.
- Finally, a 6-day run was conducted in June 1984 to demonstrate the in-situ activation and steady-state operation of a very concentrated slurry of catalyst powder.
  - Performance data were obtained over a wide range of reactor syngas space velocities, catalyst concentrations, and temperatures.
  - Mechanical performance was excellent. Post-run inspections revealed no significant equipment problems or catalyst accumulation in the system.
  - This run provided unique experience on handling high-viscosity catalyst slurries, which had never before been tried at this scale. However, catalyst activity was not as high as projected from laboratory experience.

These three runs were exceptionally encouraging from the standpoint of eventual process viability. However, they underlined two technical problems that must be solved prior to commercialization, i.e., catalyst deactivation and increased reactor productivity.

Based on evaluations of the data obtained from these runs, changes have been made to the materials of construction of the PDU to reduce the formation of metal carbonyl catalyst poisons. Improved catalyst activation procedures have also been developed and operating procedures for the PDU have been revised. A second 40-day run, using CO-rich gas, is scheduled to begin in early March to demonstrate improved catalyst activity maintenance.

A new, follow-on, 1-year contract between DOE and Air Products will be finalized in May 1985 to incorporate further process enhancements to the LaPorte PDU which will be demonstrated through an additional run. To prepare for this run and strengthen the fundamental data base, laboratory work will be carried out simultaneously to study how catalyst poisoning occurs, to define catalyst slurry criteria, and to evaluate ways of removing and adding catalyst. In addition, we plan to screen alternative catalysts, improve our fundamental computer model, and evaluate the effects of variable gas composition on catalyst performance.

Two-Year Research Program for FY 1986-1987

The LaPorte PDU is a valuable developmental tool for providing the performance data and engineering and operational experience needed to scale up the LPMEOH process to demonstration plant size. Additionally, ongoing laboratory research provides the data needed to establish a strong operating program. Our experience shows that these parallel, interrelated efforts produce the best results in a most cost-effective way when they are conducted according to a schedule that is not constrained by the administrative requirements of 1-year contracts, which prevent effective long-range planning and introduce cost inefficiencies. Consequently, to supplement the new contract work just mentioned, we have developed a plan for two years of additional work in the LaPorte PDU and supporting laboratory programs. This work will allow us to fully develop the correlations, mathematical models, and technical data required to support the design and future operation of a demonstration plant in the 100-to-200-TPD range.

The proposed FY'86-87 research program would concentrate on three main activities:

(1) Defining the limits of reactor productivity.

This activity will include: (a) defining the maximum catalyst loading and determining the effect of catalyst loading on methanol production rate; (b) defining the maximum gas throughput and determining the effect of gas velocity on methanol production rate, and the amount of catalyst carried away from the reactor; (c) testing new, potentially more active catalysts to increase methanol production; and (d) studying whether alternative liquid media can increase catalyst productivity.

(2) Developing a data base to support the design and future operation of a demonstration plant.

After a suitable catalyst and slurry loading have been selected, runs will be made in the LaPorte PDU to quantitatively define the effect of such variables as gas velocity, catalyst concentration, total pressure, and reactor temperature on syngas conversion and methanol yields. These data will be correlated and mathematical models of reactor operation will be further refined. This set of data correlations and models is necessary to provide a strong technical base for supporting the design and future operation of a demonstration plant in the 100-to-200 TPD range.

(3) Conducting catalyst-life tests.

A long run of 4-6 months duration will be made in the LaPorte PDU to more accurately determine how fast the chosen catalyst deactivates and to determine the long-term degree of catalyst durability and carry-over from the reactor.

We estimate that the cost for the two-year (FY'86-87) program will be $10.5 million, with $6.7 million required in the first year and $3.8 million required to complete the second year. We request that consideration be given for full authorization of the 2-year program costs at the beginning, since this would allow us to prepare a comprehensive technical program plan and to implement the plan most cost-effectively.

Operation of the LaPorte PDU along with its supporting programs is more than just another project in DOE's fossil energy budget. The LaPorte facility presents the country with a unique opportunity to perform cost-effective research to obtain the data and develop the technology necessary for the deployment of a synthetic fuels industry during the next period of national need. Despite the long-range nature of research at LaPorte, the fundamental attractiveness of the technology has led to strong industrial support. Both Air Products and EPRI are committed to the long-term development of LPMEOH technology and to cost-sharing in the proposed program. CSI, the originator of the technology, continues as a key partner in the research program.

Upon completion of the 2-year LaPorte LPMEOH program in fiscal years 86 and 87, the LaPorte PDU could be converted and used to develop other indirect liquefaction technologies such as the Liquid Phase Fischer-Tropsch technology now being developed at a laboratory scale with DOE support. This process will selectively produce diesel fuel from coal-derived synthesis gas.

Future Commercial Development Plan

To advance the LPMEOH process towards commercialization, the next step after completion of the LaPorte PDU program is to demonstrate the technology at a scale of about 125 tons of methanol production per day, fully integrated with an advanced coal gasifier. An ideal location for this demonstration plant is at Tennessee Valley Authority's (TVA) ammonia-from-coal facility in Muscle Shoals, Alabama, where a 200-TPD Texaco demonstration coal gasifier has been operating since 1982. Both TVA and EPRI have expressed interest in participating in such a demonstration project.

Air Products has already submitted a Statement of Interest, "Liquid Phase Methanol Demonstration Project," in response to the recent DOE Program Announcement for Information on Clean Coal Technologies for funding of such a demonstration project. The project will involve design and construction of the LPMEOH process unit, tie-in to the coal gasification unit, and operation of the integrated facility to provide necessary information for the design of commercial-scale LPMEOH plants. Successful completion of this demonstration project should set the stage for commercialization of the LPMEOH technology.

Concluding Remarks

In summary, there are a number of reasons why the government should support this key project in DOE's indirect coal liquefaction program:

1. Indirect liquefaction is a promising way to convert the nation's abundant coal resources into clean liquid fuels that can replace liquid fuels produced from imported petroleum.

2. Methanol, the end product of the LPMEOH technology, holds promise as a clean, premium fuel in a variety of applications. Methanol from domestic coal could become an important substitute for products now derived from imported petroleum.

3. The LPMEOH technology has the potential to be a more efficient, lower cost route for producing methanol from coal than conventional gas phase processes.

4. There is broad private participation in this research, and program participants are actively pursuing opportunities to advance the technology towards commercialization beyond the LaPorte PDU scale.

5. The associated technical, financial, and market risks associated with its development warrant active participation by the government in order for this technology to achieve its commercial potential.

Air Products feels strongly that the Federal Government has an important role in the development of advanced technologies of strategic value to the country. Use of the LaPorte PDU is one cost-effective way to develop such technologies, and we hope it will receive continued support.

Thank you for your attention and the opportunity to testify before your subcommittee. I will be glad to answer any questions you may have.

Statement by Frank C. Schora
President, HYCRUDE Corporation
House Science and Technology Committee
Subcommittee on Energy Development and Applications
March 11, 1985

Mr. Chairman and Members of the Subcommittee:

My name is Frank C. Schora. I am President of the HYCRUDE Corporation, which was formed in 1980 to further research and development efforts for the production of synthetic crude oil from Eastern U. S. oil shales.

One year ago, I testified before this subcommittee to recommend establishment of a research program for the production of synthet~~ic~~ fuels from the oil shales located in the Eastern United States. This subcommittee played a vital role in the establishment of an Eastern oil shale research program for fiscal year 1985. I am grateful for this opportunity to reaffirm the benefits of this program and to emphasize the need to continue this program in fiscal year 1986.

A reliable source of crude oil is vital to National security; not just for defense purposes, but for the fueling of domestic activities upon which our economy depends. The private sector has contributed heavily in the past to research and development of alternative energy sources, including Eastern oil shale. Several promising technologies are at varying stages of technical maturity as a result of those efforts. However, private sector energy research is at a low level today due to the recent drops in world oil prices and uncertainties of future pricing. Because the price of oil depends on political, as well as supply-demand forces, the burden of responsibility for the development of alternate energy sources must not fall entirely on the private sector. The time frame for realizing economic benefit from synfuels development for a corporation in most instances is so uncertain that it cannot be reasonably estimated.

This uncertainty fosters an atmosphere that is not presently conducive to the private sector support of the research and development of new alternate energy technologies and/or improvements to existing technologies.In light of the great risks involved for the Nation's security and economic well being if these technologies are not developed and improved, it is the responsibility of the government sector to maintain continuous support to synfuels research and development. This will ensure technological advancement especially during times when private industry cannot justify such R&D to stockholders.

The oil shales of the Eastern United States have established recognition as a major potential source of synthetic fuels. The central location of these oil shale deposits in close proximity to oil refining capacity, distribution networks, end markets and skilled labor force, provide strong incentive for the development of Eastern oil shale. The states of Alabama, Indiana, Kentucky, Michigan, Ohio and Tennessee contain the richest deposits of Devonian oil shales in the Eastern United States. Readily accessible deposits in these states will enable significant oil production for an extended period of time. Additionally, leaner deposits in such states as West Virginia, New York, Illinois, and Pennsylvania may become commercially feasible by application of new technology such as a combination of beneficiation and moving-bed hydroretorting, which will substantially increase oil yields.

Eastern oil shales do not have much in common with their counterpart in the Western U. S., either geologically or chemically. Mining and processing techniques necessary to utilize each of the resources most efficiently are significantly different. Eastern oil shales do not respond favorably to the conventional retorting processes used for Western oil shales. It is therefore important to conduct research to develop retorting technologies specifically for Eastern oil shale and to improve existing Eastern shale retorting technologies.

A consistent program is necessary to ensure the continuing technological advancement of new and existing technologies which are effective for processing Eastern shale in an evironmentally sound manner. In order to achieve these goals, the Eastern shale research program should include fundamental research, advanced research and environmental studies.

The inclusion of fundamental research projects in the program will ensure innovation of new process concepts designed for full utilization of Eastern oil shales.A funding level of $3.0 million in fiscal year 1986 is necessary to continue fundamental research efforts. Of this amount, HYCRUDE Corporation recommends $1.50 million to continue research activities utilizing existing equipment to improve oil shale utilization, oil yield and process efficiency for moving-bed hydroretorting and $0.75 million to continue oil shale beneficiation studies.

HYCRUDE Corporation recommends that $4.0 million be allocated for advanced research efforts in fiscal year 1986. Of that amount, $1.5 million should be allocated to continue expansion of the moving-bed hydroretorting data base.

A funding level of $2.0 million is necessary to conduct environmental studies to keep up with the advances being made in process development. Of this amount, HYCRUDE Corporation recommends $0.75 million to investigate the environmental implications of moving-bed hydroretorting and $0.50 million to investigate selective removal of sulfur from raw shale as an internal part of beneficiation.

Thank you for this opportunity to present my views to you today. I will be happy to answer any questions you may have.

EASTERN OIL SHALE

RESEARCH AND DEVELOPMENT RECOMMENDATIONS

FY 1986

PROGRAM FACT SHEET

FUNDAMENTAL RESEARCH

Hydroretorting Process Efficiency Improvement

The moving-bed hydroretorting process has been developed specifically for retorting of the Eastern oil shale resource. This process results in greatly increased resource utilization when compared to conventional thermal retorting of Eastern oil shale. However, several research areas have been identified in which the efficiency, and therefore economics, of moving-bed hydroretorting can be significantly improved.

One area is improvement of the utilization of carbon. There are two sources of organic carbon remaining after retorting: raw shale fines generated during sizing of the raw shale and spent (retorted) shale. During oil shale crushing, a significant amount of shale becomes too fine to be retorted in the moving-bed and these fines are returned to the mine unutilized. After retorting of the properly sized fraction of raw shale, approximately 15% of the original organic carbon content remains on the spent shale. Gasification of the raw shale fines and/or spent shale is one way to improve the overall utilization of carbon and it has several potential benefits. The resulting synthesis gas can be used as a fuel, or as feedstock for hydrogen production, thereby reducing the amount of natural gas which must be imported to the plant. The synthesis gas could also be directly fed to the retort, displacing some of the hydrogen requirement which would otherwise be met by conversion of natural gas. Furthermore, it is possible to produce a spent shale agglomerate which may be non-leachable.

Another area which would result in improved process efficiency is the control of oil refluxing. In a countercurrent moving-bed process, cold raw shale contacts the hot product gas containing the oil vapors. If these vapors condense as large droplets, they impinge on the shale particles and refluxing occurs. This results in the subsequent cracking of the oil to form gaseous hydrocarbons. A system which controls the size of the oil droplets will result in increased oil yields and reduced hydrogen consumption.

It has been discovered by several researchers that there is a loss of oil yield potential from thermal processing after mined shale is exposed to the atmosphere (weathering) over periods as short as several days. It is important to investigate the extent of raw shale weathering as a function of exposure time, shale particle size, etc., so that appropriate action can be taken to prevent significant loss of potential oil yield. A research effort should be supported which investigates the cause and effect of raw shale weathering on retorting oil yields.

It is also necessary to learn more about the basic kinetics of moving-bed hydroretorting so that modifications to the process can be made which will result in lower operating pressure and/or replacement of part of the hydrogen in the retorting atmosphere.

HYCRUDE Corporation recommends $1.50 million in FY '86 to improve the process efficiency of moving-bed hydroretorting.

Oil Shale Beneficiation

Beneficiation of Eastern oil shales greatly increases the potential yield of oil for a given shale by selective separation of rock from the organic portion of the shale. For example, an Indiana shale which yielded 12 gal/ton by Fischer Assay (a test which provides an oil yield analogous to thermal retorting yield) was enriched to 27 gal/ton. When this beneficiated shale was processed by moving-bed hydroretorting, the yield was increased to 54 gal/ton. Beneficiation can extend the range of shales which can be considered commercially viable including lower grade deposits in states such as Illinois, New York, Pennsylvania and West Virginia. Beneficiation of Eastern oil shales looks particularly promising when used in conjunction with moving-bed hydroretorting because some elevated pressure retorts are replaced by ambient pressure beneficiation equipment, which is less expensive.

HYCRUDE Corporation recommends $0.75 million in FY '86 to investigate beneficiation and moving-bed hydroretorting of Eastern oil shales.

Oil Shale Sample Bank

It will be useful to establish a sample bank for Eastern oil shale so that all researchers will be working on well documented shale samples. Furthermore, work performed by different researchers on the same shales will be comparable. Multi-ton samples of at least six shales will be identified, procured, and both chemically and geologically characterized.

HYCRUDE Corporation recommends $0.50 million in FY '86 to establish an Eastern oil shale sample bank.

Solvent Extraction of Kerogen

It is important to foster the development of novel retorting concepts for Eastern oil shale to ensure retorting technology advancement in the long term. Concepts such as solvent extraction of kerogen from oil shale at ambient temperature should be investigated.

HYCRUDE Corporation recommends $0.25 million in FY '86 to investigate novel retorting concepts.

ADVANCED RESEARCH

Auxiliary Process Studies

Advanced research work should be performed in several areas which are auxiliary to any Eastern oil shale retorting process. The method of preparation of oil shale feedstock by crushing and screening is important to moving-bed retorting technologies, as this consumes energy and generates fines which cannot be processed in these retorts. Methods for oil shale crushing which minimize energy consumption and produce a closely controlled size range of crushed shale, thereby reducing fines waste, should be investigated.

In order to improve the overall plant energy balance, the use of anaerobic processing methods to produce fuel gas from organic contaminants in the retort waste water should be investigated.

The efficient separation of water and fines from the oil produced during retorting is an important element of producing raw shale oil of consistent quality. Improved methods for separation of water and fines from shale oil such as the use of electrical fields should be developed and tested.

HYCRUDE Corporation recommends $0.5 million in FY '86 to carry out advanced research projects on systems such as shale crushing, shale weathering, and oil/water separation which are ancillary to the retorting system itself.

Expansion of Hydroretorting Data Base

Moving-bed hydroretorting is a process which has been developed specifically for retorting of Eastern oil shale. It has been proven to result in enhanced oil yields from Eastern shales which are as great as twice the oil yields obtainable using conventional thermal retorting methods. The majority of the Eastern oil shale hydroretorting data base has been obtained for an Indiana New Albany shale. It is necessary to perform further work to expand the process and environmental data base to other types of Eastern shale.

The crushing and screening of raw shale to produce the size range desired for moving-bed retorting results in some fines generation.The gasification of shale fines with production of an agglomerated spent shale product is an alternative to returning raw shale fines to the mine. This provides more efficient utilization of the resource and a virtually nonleachable spent shale product. Adiabatic fines gasification tests will be conducted on the shales for which gasification characteristics have been determined.

Expansion of Hydroretorting Data Base (contd)

The ability to process more shale fines in the moving bed is another alternative for increasing resource utilization and improving process economics. Cold-Flow Modeling tests should be conducted for moving bed hydroretorting to determine the allowable size range for feed shale.

Additionally, experimental work should be performed to evaluate the heat of reaction for moving-bed hydroretorting and to determine the effect of raw shale weathering on hydroretorting oil yields. The heat of reaction has an impact on the overall thermal efficiency of the process and varies depending on the amount of raw shale carbon which is converted to gas or oil. The mechanism for raw shale weathering is not understood, but experimental data suggest that weathered shale requires more hydrogen for hydroretorting.

HYCRUDE Corporation recommends $1.50 million in FY '86 to expand the data base for moving-bed hydroretorting.

Scaleability of Fast Heat Up Retorting Processes

The scaleup issues (oil yield versus equipment size) should be investigated for novel methods of Eastern oil shale retorting including fast heatup, fluidized bed thermal retorting, which has shown promising oil yields to date.

HYCRUDE Corporation recommends $0.5 million in FY '86 to further investigate fast heatup retorting methods.

Advanced Process Studies

Advanced process studies must be performed for promising Eastern shale retorting processes to verify technical, economic and/or environmental aspects of retorting on a larger scale in the Eastern states. These issues are of particular interest to state agencies which may also participate in the support of advanced process studies.

HYCRUDE Corporation recommends $1.00 million in FY '86 to supplement the support of advanced process studies by state-supported governmental agencies.

Data Book

Now that more varied research work is being performed on Eastern oil shale by both private concerns and government agencies, a computerized data base and a data book should be compiled to assure ready access of such data to all researchers.

HYCRUDE Corporation recommends $0.50 million in FY '86 to compile a computerized data base and a data book.

ENVIRONMENTAL STUDIES

Environmental Impact of Moving-Bed Hydroretorting

Detailed, site-specific environmental analyses of the moving-bed hydroretorting data base should be performed including the impacts on air and water quality. Detailed studies of spent shale disposal should also be performed.

HYCRUDE Corporation recommends $0.75 million in FY '86 to investigate the environmental impact of moving-bed hydroretorting.

Raw Shale Desulfurization

It is possible that removal of pyritic sulfur from the raw shale can be accomplished as part of an oil shale beneficiation process by froth flotation and/or magnetic separation.

HYCRUDE Corporation recommends $0.50 million in FY '86 to investigate the removal of sulfur from raw shale via beneficiation.

Basic Environmental Studies

Evaluation of the environmental impacts of any evolving technology should keep pace with the process research work being conducted. It is therefore recommended that the environmental implications of oil shale beneficiation, gasification, solvent extraction, and fast heatup retorting processes be investigated.

It is also recommended that baseline environmental data be gathered for the regions which would be affected by an Eastern oil shale retorting industry. Data on existing point sources of sulfur and nitrogen oxides and on the seasonal availability of water should be gathered and the potential effects of a shale oil industry evaluated.

HYCRUDE Corporation recommends $0.75 million in FY '86 to perform environmental studies on newly emerging Eastern shale retorting technologies, and to perform baseline environmental studies.

APPENDIX II

ADDITIONAL QUESTIONS AND ANSWERS FOR THE RECORD

POST-HEARING QUESTIONS AND ANSWERS

RELATED TO THE

MARCH 6, 1985, HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

WITNESS: ASSISTANT SECRETARY WILLIAM VAUGHAN

Question 1: A recent article in Inside Energy reports that a panel of the Department of Energy's Research Advisory Board (ERAB) is expected to recommend this spring that "DOE must invest more dollars in clean coal technology R&D for existing plants and make a policy shift towards funding larger-scale demonstrations". In light of this anticipated support for increased federal funding within DOE's own advisory board, I am interested in knowing how much you will rely on ERAB's recommendation in considering an appropriation request for the Clean Coal Technology Reserve.

Answer: ERAB is a Secretarial level advisory board, and performs studies at the request of the Secretary. In this vein, ERAB recommendations are given serious consideration in the development of programs and their associated budgets. The forthcoming ERAB report on Clean Coal Technology R&D will receive such consideration with respect to the technologies it discusses. However, the Department has no plans to request a separate appropriation related to funds authorized for the Clean Coal Technology Reserve.

Question 2: Researchers at Virginia Tech and United Coal Company are optimistic about the potential for smokeless solid fuels to be directly substituted for wood in wood heating stoves. This new fuel form is attractive due to its reduced emissions of nitrogen oxides and its improvement of space heat efficiency. Further research is needed, however, to test out the fuel at a larger scale and at different temperatures and ash levels. What plans does the Department of Energy have for continuing and accelerating the promising research on smokeless solid fuels?

Answer: Smokeless solid fuel is not a new technology since the production of smokeless solid fuels for commercial use has been conducted for 30 to 40 years in the United Kingdom. However, DOE sees considerable merit in further exploring the use of char, a smokeless solid fuel, to extend U.S. coal use. In addition, by-products of related processing technologies may have even greater value than char, due to their potential to substitute directly for oil and gas in some energy consuming machines. The Department, consequently, is currently evaluating the potential of the smokeless solid fuels, as well as the other coal-derived fuel forms, to extend the use of coal into the non-utility sectors. It is possible that smokeless solid fuels would find their first commercial application as a wood substitute for domestic heating, since by definition that is a small scale application that does not need larger scale testing.

Question 3: With reference to the Magnetohydrodynamics (MHD) Project, what was the Department of Energy's original budget request this year to the Office of Management and Budget?

Answer: The FY 1986 OMB budget request for the MHD program was $29,321,000. This amount was for the continuation of the multiyear program initiated in FY 1985 and targeted on the continuation of proof-of-concept development and testing.

Question 4: What happened to the request and was there an appeal? If there was no appeal, why not?

Answer: DOE did not appeal the OMB allowance which eliminated funding for the MHD program. In light of severe budgetary constraints, the Department has reassessed its priorities among all of the diverse fossil energy technologies and determined that other technologies could contribute more generic information across a broader range of energy markets, at lower investment requirements, and with significantly more cost sharing. MHD is considered to have development risks and costs which are not affordable in light of current fiscal contraints.

Question 5: What is your intention with respect to the $15 million deferral on MHD now before the Congress?

Answer: In conjunction with the President's FY 1986 budget submission, the Department of Energy has proposed to defer $48.397 million in FY 1985 and prior year funds appropriated to Fossil Energy Research and Development, $15 million of which was to come from the MHD budget.

The MHD technology is considered a long-term technology which has high development risks and costs and is not affordable nor of highest priority in light of current fiscal constraints upon DOE. Furthermore, we believe the private sector is in a position to continue to develop MHD technology commensurate with utility needs, based on the Federal Government's efforts to date. In view of these factors, it has become necessary to phase out this development effort.

In order to facilitate the phase out of the Department's efforts, the proof-of-concept activities initiated in FY 1985 were scheduled for termination on March 31, 1985, with plans to be made for the disposition of government-owned equipment and facilities. As a result, the Department proposed a deferral of $15,000,000 of FY 1985 appropriations. In response to a request from the Committee on Appropriations, however, the Department will amend the deferral to $12,500,000 to permit the continuation of MHD activities through May 1, 1985.

Question 6: How is the present situation reconciled with the public meetings with the MHD Industrial Forum last year in which the U.S. Government and the MHD community agreed to move forward on a retrofit MHD project after the proof-of-concept phase was completed?

Answer: Early in 1984, DOE, in consultation with the private sector, realigned the MHD program. The historic program, which focused on subsystems development, was redirected to a multi-year, cost-shared program targeted on proof-of-concept (POC) testing. The total cost of the POC program, including private sector cost sharing, was estimated to be approximately $150 million. The POC program was to have been completed in 1989. By the end of FY 1984, however, there was no indication from the private sector that significant cost sharing would be forthcoming. The Department, therefore, reassessed its priorities for fossil energy technologies and determined that other fossil energy technologies could contribute more directly to DOF needs and national energy security in shorter time frames, with lower investment requirements, and with significantly more cost sharing. Therefore, the Department proposed to terminate the MHD program in FY 1985, and to turn over the major facilities and equipment to the private sector for continued development.

Question 7: Regarding the agreement with EPRI for use of the Homer City Facility, are there any plans to test this coal in an actual combustion system to see how it performs, comparing it to say, "dirty" coal and conventionally-cleaned coal? How much money is budgeted for this purpose?

Answer: The purpose of the Department of Energy's project agreement with the Electric Power Research Institute (EPRI) is to test new advanced physical fine-coal cleaning technologies that are ready for evaluation at a nominal scale of one ton of coal processed per hour. These processes will be evaluated at EPRI's Coal Cleaning Test Facility in Homer City, Pennsylvania. We are requiring that technologies proposed for this program be capable of reducing the pyritic sulfur content of any given bituminous coal beyond the reduction achievable by today's state-of-the-art coal cleaning processes. The resultant clean coal product should contain no more than 2 percent ash and less than 30 percent moisture. Accordingly, from the results of the tests and by assaying the clean coal product, we expect to know the pollution-related properties of the coal and its advantages as compared with conventionally-cleaned coal without the need to actually burn it in a boiler. Under our Alternative Fuels Program (the Combustion Engineering contract), we have already examined the combustion and handling effects of coal-water mixture fuels containing coals cleaned to 2 percent ash. Consequently, no funds have been budgeted to do combustion testing as part of the EPRI/DOE agreement on coal cleaning at Homer City as such actual combustion testing is not viewed as necessary for the successful completion of this project.

Question 8: I notice a significant reduction in the budget for alternative fuels which concerns me since the goal of the program is to find coal-based replacements for oil and gas. Specifically, I noticed that a 1985 activity was approximately $2 million for "combustion characterization and phenomena identification for coal-liquid mixture technology areas applicable to heat engine systems" (p. 68). Are these studies to continue in 1986?

Answer: The FY 1985 Alternative Fuels activity includes the completion of a utility and large industrial boiler/furnace data base for CLM retrofit use, as well as generic combustion characterization efforts for heat engines ("combustion characterization and phenomena identification for coal-liquid mixture technology areas applicable to heat engine systems"). The amount specified for heat engines in FY 1985 completes the preliminary phase of our CLM fuel-for-heat-engines characterization activities. At this point in our program, we expect the characterization data to be sufficient to determine, in a generic sense, the technical potential for CLM fuel in heat engines and to identify specifically promising concepts. These data will then be made available to the Heat Engines Program for the selection of the most promising turbine and diesel concepts. Within the auspices of the Heat Engines Program, these selected concepts will undergo detailed combustion and component characterizations and developmental efforts will be pursued as deemed necessary to generate a commercially acceptable user database for turbine and diesel system applications.

The FY 1986 budget request for the Alternative Fuels activity does not include combustion characterization efforts for heat engines. Rather, our budget request shifts its concentration from heat engine applications to the more promising (in terms of potential for oil and gas backout) light industrial, commercial and residential sectors where organized R&D support is practically non-existent. We believe the FY 1986 budget requirements for addressing these areas will be less than that required for the larger and more costly systems being completed in our FY 1985 program; hence, a reduction in our FY 1986 budget request for the FY 1986 Alternative Fuels Program.

Question 9: I notice that for estimated 1985 activities under flue gas cleanup you mention that you "initiated a competitive procurement for evaluation of acid rain precursor control technology at the proof-of-concept scale". How much money is set aside for this? How many projects could this fund? Would you agree to add more money for this should there prove to be more worthwhile proposals submitted to the Department?

Answer: In FY 1985, $2,950,000 has been appropriated for this procurement. An additional $5,320,000 million was requested in the FY 1986 budget. We estimate funding a minimum of two projects, depending on estimated project costs and the amount of cost- sharing offered by the proposers.

At this time, the proposals received in response to the subject procurement are currently being evaluated. In accordance with procurement regulations, we are not permitted to release any information related to the proposals during the evaluation process. By the end of April, we will be in a better position to state how many worthwhile proposals have been received along with associated funding requirements.

Question 10: I noticed that the advanced research for both liquefaction and gasification has been moved from the AR&TD functions into the line programs. As you point out in the budget, these programs are distinguished from the line programs in that they emphasize the small scale, fundamental studies in coal liquefaction. Why was this done? Would the Department be adverse to moving them back?

Answer: For the FY 1986 Congressional Budget request, the advanced research programs for both coal liquefaction and coal gasification are included with their respective programmatic budget requests. However, the management and administration of these programs remains unchanged. This is still performed by Fossil Energy's AR&TD function.

The budget structure was changed in response to Congressional direction contained in Conference Report 98-1159, page 261, on the Department of Interior and Related Agencies Appropriations Act, 1985 (P.L. 98-473):

> "The managers expect that future budget justification for advanced research and technology development will include only those activities which are truly program cross-cutting. Gasification and liquefaction items, for example, should be budgeted in their respective programs rather than as part of advanced research and technology development."

The Department would not be adverse to reporting these functions as a part of the AR&TD activity if Congress prefers the former structure.

Question 11: I notice a sizeable reduction in the liquefaction program. Will these cuts have any impact on the operation of the liquefaction data base management activities?

Answer: The liquefaction data base management activities are funded from the Support Studies/Engineering Evaluations budget category. In FY 1986, $4,279,000 is requested for this category, a decrease of $1,425,000 from the $5,704,000 appropriated in FY 1985. The FY 1986 budget request includes $700,000 for data base management activities. This is only a modest reduction from the $787,000 allocated for this activity in FY 1985 and should not greatly impact the operation of this activity. The FY 1986 request will provide for completion of the data base acquisition from the previous major liquefaction project activities (SRC-I, SRC-II, H-Coal, EDS) and allow further analysis and consolidation of the data.

DON FUQUA, Florida, Chairman

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Republican Staff Director

April 17, 1985

Hon. William A. Vaughan
Asst. Secretary for Fossil Energy
U.S. Department of Energy
Washington, D.C. 20585

Dear Mr. Vaughan:

The attached questions supplement discussions held during the Energy Development and Applications Subcommittee hearing on March 6, 1985, relative to the FY 1986 fossil energy budget request.

Please provide response within a reasonable period for inclusion in the hearing record.

Sincerely,

Don Fuqua

DON FUQUA
Chairman

DF:Hcw
attachment

Additional Questions for Hon. William A. Vaughan
Hearing, March 6, 1985

1. A recent article in Inside Energy reports that a panel of the Department of Energy's Energy Research Advisory Board (ERAB) is expected to recommend this spring that "DOE must invest more dollars in clean coal technology R&D for existing plans and make a policy shift towards funding larger-scale demonstrations." In light of this anticipated support for increased federal funding within DOE's own advisory board, I am interested in knowing how much you will rely on ERAB's recommendation in considering an appropriation request for the Clean Coal Technology Reserve.

2. Researchers at Virginia Tech and United Coal Company are optimistic about the potential for smokeless solid fuels to be directly substituted for wood in wood heating stoves. This new fuel form is attractive due to its reduced emissions of nitrogen oxides and its improvement of space heat efficiency. Further research is needed, however, to test out the fuel at a larger scale and at different temperatures and ash levels. What plans does the Department of Energy have for continuing and accelerating the promising research on smokeless solid fuels?

3. With reference to the magnetohydrodynamic (MHD) project, what was the Department of Energy's original budget request this year to the Office of Management and Budget?

4. What happened to the request and was there an appeal? If there was no appeal, why not?

5. What is your intention with respect to the $15 million on deferral on MHD now before the Congress?

6. How is the present situation reconciled with the public meetings with the MHD Industrial Forum last year in which the U.S. Government and the MHD community agreed to move forward on a retrofit MHD project after the proof of concept phase was completed?

7. Regarding the agreement with EPRI for use of the Homer City Facility, are there any plans to test this coal in an actual combustion system to see how it performs, comparing it to say, "dirty" coal and conventionally-cleaned coal? How much money is budgeted for this purpose?

8. I notice a significant reduction in the budget for alternative fuels which concerns me since the goal of the program is to find coal-based replacements for oil and gas. Specifically, I noticed that a 1985 activity was approximately $2 million for "combustion characterization and phenomena identification for coal-liquid mixture technology areas applicable to heat engine systems." (p.68). Are these studies to continue in 1986?

9. I notice that for estimated 1985 activities under flue gas cleanup you mention that you "initiated a competitive procurement for evaluation of acid rain precursor control technology at the proof of concept scale." How much money is set aside for this? How many projects could this fund? Would you agree to add more money for this should there prove to be more worthwhile proposals submitted to the Department?

10. I noticed that the advanced research for both liquefaction and gasification has been moved from the AR&TD functions into the line programs. As you point out in the budget, these programs are distinguished from the line programs in that they emphasize the small scale, fundamental studies in coal liquefaction. Why was this done? Would the Department be adverse to moving them back?

11. I notice a sizeable reduction in the liquefaction progam. Will these cuts have any impact on the operation of the liquefaction data base management activities?

Department of Energy
Washington, DC 20585

August 7, 1985

Honorable F. James Sensenbrenner, Jr.
Ranking Minority Member
Subcommittee on Energy Development
  and Applications
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Sensenbrenner:

On March 6, 1985, Assistant Secretary William A. Vaughan appeared before the Science and Technology Subcommittee on Energy Development and Applications to discuss the Department's Fiscal Year 1986 request for the Fossil Energy Programs.

With your letter dated July 25, 1985, you submitted questions for our response to supplement the record. Enclosed for your information are answers to those questions which also have been sent to the Committee staff.

If you have any questions, please have your staff call Ingrid Nelson or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

POST-HEARING QUESTIONS AND ANSWERS

RELATED TO THE

MARCH 6, 1985 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

U.S. HOUSE OF REPRESENTATIVES

WITNESS: ASSISTANT SECRETARY VAUGHAN

QUESTIONS SUBMITTED BY: CONGRESSMAN SENSENBRENNER

PROPOSED MHD PHASE-OUT

Question: If the reason for the proposed MHD phase-out is the high cost of the next phase of MHD development, something we just can't afford at this time, is DOE leaving itself open for the possibility of MHD funding resurfacing when the economic climate improves, or has DOE given up entirely on the technical feasibility and energy potential of this technology?

Answer: DOE has not given up on the technical feasibility and energy potential of MHD and we will continue to monitor the development of MHD technology. However, the MHD program is extremely costly and, given the severe budgetary constraints, the Department has reassessed its priorities for fossil energy technologies and determined that other technologies could contribute more directly to achieving its objectives for national energy security with lower investment requirements, in a more timely fashion, and with significantly more cost sharing.

PHOSPHORIC ACID FUEL CELLS

Question: Over the last ten years, over $300 million in federal funding has been provided to establish the technical feasibility of phosphoric acid fuel cells. This is a substantial investment, one we don't want to see wasted. Are you confident the industries involved in this effort to date will continue to advance the technology on their own?

Answer: Phosphoric acid fuel cells have reached the development stage (post proof-of-concept) that it is now appropriate for the private sector to continue the final development work and the commercialization of the technology. It should be noted that approximately $200 million in federal funding has been appropriated for the DOE Phosphoric Acid Fuel Cell program and an expenditure of $400 million has been made by the private sector. Also, evidence of this mature state of the technology is that two manufacturers contemplate commercial offerings and prototype powerplants deliveries by about 1988. Another manufacturer is presently developing/negotiating commercial plans. In addition, preprototype phosphoric acid on-site fuel cell powerplants have to date accumulated over 100,000 operating hours in gas utility service. Based upon this evidence, we believe the industry will continue their successful technology development efforts.

FY 1986 BUDGET REQUEST

Question: With respect to the Department's overall budget request for FY 1986, the Committee recognizes the urgency of reducing federal spending, but, do you believe DOE has adequately balanced, or distributed, these demands for increased austerity? Do the short-term savings of drastically reducing some of the fossil energy programs in FY 1986 outweigh the potential costs associated with terminating these programs prematurely?

Answer: Fossil Energy's FY 1986 budget request strikes a balance between the economic urgency of limiting government spending and the technological necessity of maintaining a sound, progressive program of long-range, high-risk, generic R&D. The decisions reflected in this budget request have been made within the context of the urgent national need to reduce federal spending. This overriding fiscal priority has meant, in some cases, that not all legitimate, technologically sound energy concepts can be pursued. For some processes, particularly those in more advanced stages of maturity, it has meant that federal involvement will proceed to the proof-of-concept stage, at which point industry can elect to demonstrate or commercialize the particular technology. And for some efforts, particularly those that require major capital outlays for large facilities, fiscal considerations have necessitated that the government offer equipment and facilities in lieu of direct funding.

The FY 1986 budget request does not provide funding for the continuation of the Phosphoric Acid Fuel Cell (PAFC) program or the Magnetohydrodynamics (MHD) program. We do not believe that these reductions will have a serious effect on Fossil Energy R&D efforts since a significant amount of Federal research has been performed on these technologies. By FY 1986, the development of the PAFC technology will be advanced well beyond the proof-of-concept stage. PAFC systems have matured to the point that two manufacturers (United Technologies/International Fuel Cell Corporation and

Westinghouse) contemplate commercial offerings and prototype powerplants deliveries in the next three years. Also, Engelhard is presently developing/negotiating commercial plans. Accordingly, it is now appropriate for DOE to close out its support for PAFC systems. Some generic research in electrochemistry and surface science that is continuing elsewhere in fossil energy may have long term spinoffs relevant to PAFC designs. The MHD program requires a very expensive development program to bring the technology to the point of commercial acceptance. It is estimated that $150 million is needed for the proof-of-concept work and an additional $350 million for a demonstration plant. These expenditures assume significant cost sharing by the private sector. The Fossil Energy program as proposed offers the best technical balance that can be achieved under current economic conditions. The termination costs for MHD are relatively small compared to the new investments still required to carry out the next phases of the program.

CONTINUATION OF INDUSTRIES R&D EFFORTS

Question: What indication have you received from the cost-sharing industries in the R&D programs which are proposed for such enormous cuts that they will continue their efforts in the absence of federal support?

Answer: United Technologies and Westinghouse contemplate commercial offerings and prototype powerplants deliveries by about 1988. Also, Engelhard is presently developing/negotiating commercial plans. We do not believe the government's withdrawal from the Phosphoric Acid Fuel Cell program will impact any commercial ventures underway in this technology. For MHD, we have not yet received any indication from industry that they will pursue MHD R&D on their own. Nor has any cost sharing proposal been received in the past year in connection with the Department's technology base efforts. However, we believe the private sector is in a position to continue to develop MHD technology if they really want to, based on the Federal Government's efforts to date. It is anticipated that the large amount of equipment and facilities having significant value and owned by the government can be made available to private industry in a manner that will allow industry to continue the development of the technology consistent with their interest and funding availabilities.

ACID RAIN RELATED RESEARCH

Question: Given our nation's concern over the acid rain problem, and the possibility that sulfur dioxide emissions from coal-fired power plants may contribute to this phenomenon, how do you justify a 23 percent reduction in funding for the Control Technology and Coal Preparation program?

Answer: The national energy policy in the area of acid rain has supported accelerated research to determine how acidic compounds are formed in the atmosphere and the relationship between air emissions and acid deposition effects. The objective continues to be one of achieving a scientific understanding of the atmospheric physics and chemistry and related characteristics of the acid rain phenomenon and of avoiding premature or excessive regulations that might significantly increase consumer prices without providing corresponding benefits in controlling acid rain.

The DOE activities aimed specifically at the development of controls for retrofit to existing power plants were initiated in FY 1985 and we are in fact making considerable progress.

In coal preparation we have solicited proposals for advanced fine coal cleaning technologies to be tested in EPRI's Coal Cleaning Test Facility in Homer City, Pa. These proposals are presently being evaluated, and multiple awards are expected to be made by the end of FY 1985. Funding for this important effort is about $7 million in FY 1985 and FY 1986.

In the area of flue gas cleanup, the Department solicited concepts for low cost, retrofittable flue gas treatment processes for the control of acid rain precursor emissions, and recently announced the selection of four concepts for support. FY 1985 funding for this project is $3 million.

The decrease in funding for the Control Technology and Coal Preparation program includes reductions in flue gas cleanup, which come primarily from the combined SO_x/NO_x program, since there does not appear to be any concepts from the 1983 PRDA, which are ready for proof-of-concept tests. Additional reductions in flue gas cleanup include the demonstration of the Glo-Klen process and the evaluation of combined NO_x/SO_x control in dry scrubbers which were FY 1985 Congressional add-ons. The major reductions in gas stream cleanup are the on-line coal gasification tests of selected particulate and sulfur removal devices for gasifier/turbine combined cycles, which will continue at a reduced level of effort in FY 1986; and the contaminant control tests for soot and particulate trace metals, which will be completed in FY 1986 and an evaluation prepared. There is a small reduction in solid waste cleanup funding due to the completion of the RCRA related studies. The small reduction in coal preparation represents the completion of the Southern Illinois University (SIU) Cooperative Agreement but doesn't reduce the acid rain control effort, and the FY 1985 Congressionally directed support of the purged carbon process for which no funding is requested in FY 1986.

MHD

Question: DOE's justification for terminating the MHD program is quite confusing. As stated in the budget, "the MHD program is believed to be a costly, long-range, high-risk effort." Yet, the Reagan Administration philosophy for the last four years has been to specifically fund only long-term, high-risk R&D which the private sector cannot be expected to perform on their own. How do you explain this inconsistency in policy?

Answer: We agree that MHD is a long-term, high-risk technology; however, it is extremely costly and in light of the severe budgetary constraints the Department has reassessed its priorities for fossil energy technologies and determined that other technologies could contribute more directly to achieving DOE's objectives with lower investment requirements, in a more timely manner, and with significantly more cost sharing. In addition, construction of a demonstration plant is expected to require an additional $350 million of federal funding. MHD is considered to have development risks and costs which are not affordable in light of current fiscal constraints. The MHD multiyear preliminary transition and program plan submitted to Congress in June 1984 called for an expenditure of approximately $150 million with significant cost sharing. As we approach the end of FY 1985, following a year of meetings with the private sector, there is no firm indication from the private sector that significant cost sharing for proof-of-concept testing is forthcoming. For these reasons, the Department proposes to terminate the MHD program in FY 1985 and no funds have been requested in FY 1986 for MHD.

PRESSURIZED FLUIDIZED BED COMBUSTION

Question: DOE is requesting approximately $2.8 million more in FY 1986 for Pressurized Fluidized Bed Combustion R&D so they can initiate a cost-share program with industry for a second generation, advanced cycle system. To what degree would the second generation system be superior to the steam-cooled PFBC system?

Answer: The PFB advanced concepts program would provide the system design and economic foundation for second generation coal-fired systems. Second generation, advanced cycle projects would build upon the current PFB program in extending the technology to develop substantially higher payoff, high risk PFB systems. Performance goals for second generation advanced systems would include process efficiency of at least 45 percent and cost of electricity reductions of at least 20 percent below conventional pulverized coal-fired boilers with flue gas desulfurization. Present steam cooled PFBC systems are estimated to have a process efficiency of 40 percent and would reduce the cost of electricity by approximately 10 percent over existing coal-fired power plants.

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Republican Staff Director

July 25, 1985

Honorable William A. Vaughan
Assistant Secretary, Fossil Energy
U.S. Department of Energy
Washington, D.C. 20585

Dear Mr. Vaughan:

Thank you for your testimony before the Subcommittee on Energy Development and Applications on March 6, 1985 on the Department's FY 1986 request for Fossil Energy programs. Attached are a number of questions the Republicans on the Subcommittee would like you to answer, in order to supplement the record of the hearing on this topic.

If you have questions regarding this request, please contact Tom Weimer, Minority Energy Coordinator, at 225-1624.

Sincerely,

F. JAMES SENSENBRENNER, JR.,
Ranking Member, EDA Subcommittee

1. With respect to the Department's overall budget request for FY 1986, the Committee recognizes the urgency of reducing federal spending, but, do you believe DOE has adequately balanced, or distributed, these demands for increased austerity? Do the short-term savings of drastically reducing some of the fossil energy programs in FY 1986 outweigh the potential costs associated with terminating these programs prematurely?

2. What indications have you received from the cost-sharing industries in the R&D programs which are proposed for such enormous cuts that they will continue their efforts in the absence of federal support?

3. Over the last ten years, over $300 million in federal funding has been provided to establish the technical feasibility of phosphoric acid fuel cells. This is a substantial investment... one we don't want to see wasted. Are you confident the industries involved in this effort to date will continue to advance the technology on their own?

4. DOE's justification for terminating the MHD program is quite confusing. As stated in the budget, "the MHD program is believed to be a costly, long-range, high-risk effort." Yet, the Reagan Administration philosophy for the last four years has been to specifically fund only long-term, high-risk R&D which the private sector cannot be expected to perform on their own. How do you explain this inconsistency in policy?

5. If the reason for the proposed MHD phase-out is the high cost of the next phase of MHD development... something we just can't afford at this time, is DOE leaving itself open for the possibility of MHD funding resurfacing when the economic climate improves, or has DOE given up entirely on the technical feasibility and energy potentia of this technology?

6. Given our nation's concern over the acid rain problem, and the possibility that sulfur dioxide emissions from coal-fired power plants may contribute to this phenomenon, how do you justify a 23 percent reduction in funding for the Control Technology and Coal Preparation program?

7. DOE is requesting approximately $2.8 million more in FY 1986 for Pressurized Fluidized Bed Combustion R&D so they can initiate a cost-share program with industry for a second generation, advanced cycle system. To what degree would the second generation system be superior to the steam-cooled PFBC system?

POST-HEARING QUESTIONS AND ANSWERS

RELATED TO THE

MARCH 6, 1985 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

U.S. HOUSE OF REPRESENTATIVES

WITNESS: ASSISTANT SECRETARY VAUGHAN

QUESTIONS SUBMITTED BY: CONGRESSMAN FAWELL

ARGONNE NATIONAL LAB

Question: As you know, Argonne National Laboratory conducts many research activities which are funded under the Fossil Energy Program. For instance, MHD-related R&D is performed and efforts are carried out in the coal gasification field. Consequently, I am very concerned over the impact a 30% funding reduction in fossil energy R&D will have on this valuable lab.

Could you please provide me with detailed information on what Argonne activities would be affected by the Department´s budget request, and to what extent? Please include funding cutbacks by program area and the expected manpower reductions this would entail.

Answer: The following table reflects the FY 1985 and FY 1986 Fossil Energy R&D allocations for Argonne National Laboratory and the changes for each program area, including expected manpower increases/reductions.

	($ in thousands)			(FTE´s)
Program Area	FY 1985	FY 1986	Change	Manpower Inc./Dec.
Cont. Tech. and Coal Prep.	$ 1,574	$ 445	$-1,129[1/]	-11.0
Adv. Research & Tech. Devmt.	3,158	2,681	-477	-5.3
Coal Liquefaction	200	0	-200	-2.7
Combustion Systems	143	250	+107	+1.2
Fuel Cells	650	900	+250	-3.4
Heat Engines	170	0	-170	-2.0
Underground Coal Gasification	0	0	0	0
Magnetohydrodynamics	482	0	-482	-9.7
Surface Coal Gasification	1,250	663	-587	-9.2
Total Coal	$ 7,627	$ 4,939	$-2,688	-42.1
Unconventional Gas Recovery	$ 0	$ 0	$ 0	0
Advanced Process Technology	$ 0	$ 0	$ 0	0
Enhanced Oil Recovery	0	0	0	0
Oil Shale	0	0	0	0
Total Petroleum	$ 0	$ 0	$ 0	0
Capital Equipment	$ 35	$ 0	$ -35	0
TOTAL FOSSIL ENERGY R&D	$ 7,662	$ 4,939	$-2,723	-42.1

1/ For FY 1985, there was a Congressional add-on of $1.2 million for an evaluation of combined NO_x/SO_x control in a dry scrubber process. No funds have been requested in FY 1986 for this project.

FY 1986 BUDGET REQUEST

Question: With respect to the Department's overall budget request for FY 1986, the Committee recognizes the urgency of reducing federal spending, but, do you believe DOE has adequately balanced, or distributed, these demands for increased austerity? Do the short-term savings of drastically reducing some of the fossil energy programs in FY 1986 outweigh the potential costs associated with terminating these programs prematurely?

Answer: Fossil Energy's FY 1986 budget request strikes a balance between the economic urgency of limiting government spending and the technological necessity of maintaining a sound, progressive program of long-range, high-risk, generic R&D. The decisions reflected in this budget request have been made within the context of the urgent national need to reduce federal spending. This overriding fiscal priority has meant, in some cases, that not all legitimate, technologically sound energy concepts can be pursued. For some processes, particularly those in more advanced stages of maturity, it has meant that federal involvement will proceed to the proof-of-concept stage, at which point industry can elect to demonstrate or commercialize the particular technology. And for some efforts, particularly those that require major capital outlays for large facilities, fiscal considerations have necessitated that the government offer equipment and facilities in lieu of direct funding.

The FY 1986 budget request does not provide funding for the continuation of the Phosphoric Acid Fuel Cell (PAFC) program or the Magnetohydrodynamics (MHD) program. We do not believe that these reductions will have a serious effect on Fossil Energy R&D efforts since a significant amount of Federal research has been performed on these technologies. By FY 1986, the development of the PAFC technology will be advanced well beyond the proof-of-concept stage. PAFC systems have matured to the point that the three principal manufacturers (United Technologies, Westinghouse and Engelhard) contemplate commercial offerings and prototype powerplants deliveries by about 1988. Accordingly, it is now appropriate for DOE to withdraw any further funding for PAFC systems. The MHD program requires a very expensive development program to bring the technology to the point of commercial acceptance. It is estimated that $150 million is needed for the proof-of-concept work and an additional $350 million for a demonstration plant. These expenditures assume significant cost sharing by the private sector. The Fossil Energy program as proposed offers the best technical balance that can be achieved under current economic conditions. The termination costs for MHD are relatively small compared to the investment required to carry out the program.

MHD

Question: DOE's justification for terminating the MHD program is quite confusing. As stated in the budget, "the MHD program is believed to be a costly, long-range, high-risk effort." Yet, the Reagan Administration philosophy for the last four years has been to specifically fund only long-term, high-risk R&D which the private sector cannot be expected to perform on their own. How do you explain this inconsistency in policy?

Answer: We agree that MHD is a long-term, high-risk technology; however, it is extremely costly and in light of the severe budgetary constraints the Department has reassessed its priorities for fossil energy technologies and determined that other technologies could contribute more generic information across a broader range of energy markets at lower investment requirements, and with significantly more cost sharing. MHD is considered to have development risks and costs which are not affordable in light of current fiscal constraints. As stated previously, the MHD multiyear preliminary transition and program plan called for an expenditure of approximately $150 million with significant cost sharing. By the end of CY 1984, following nearly a year of meeting with the private sector, there was no firm indication from the private sector that significant cost sharing for proof-of-concept testing would be forthcoming. For these reasons, the Department proposes to terminate the MHD program in FY 1985 and no funds have been requested in FY 1986 for MHD.

PHOSPHORIC ACID FUEL CELLS

Question: Over the last ten years, over $300 million in federal funding has been provided to establish the technical feasibility of phosphoric acid fuel cells. This is a substantial investment, one we don't want to see wasted. Are you confident the industries involved in this effort to date will continue to advance the technology on their own?

Answer: Phosphoric acid fuel cells have reached the development stage (post proof-of-concept) that it is now appropriate for the private sector to continue the final development work and the commercialization of the technology. It should be noted that approximately $200 million has been appropriated for the DOE Phosphoric Acid Fuel Cell program and an expenditure of $400 million has been made by the private sector. Also, evidence of this mature state of the technology is that the three principal manufacturers contemplate commercial offerings and prototype powerplants deliveries by about 1988. In addition, preprototype phosphoric acid on-site fuel cell powerplants have to date accumulated over 90,000 operating hours in gas utility service. Based upon this evidence, we believe the industry will continue their successful technology development efforts.

CONTINUATION OF INDUSTRIES R&D EFFORTS

Question: What indication have you received from the cost-sharing industries in the R&D programs which are proposed for such enormous cuts that they will continue their efforts in the absence of federal support?

Answer: United Technologies, Westinghouse and Engelhard contemplate commercial offerings and prototype powerplants deliveries by about 1988. We do not believe the government's withdrawal from the Phosphoric Acid Fuel Cell program will impact any commercial ventures underway in this technology. For MHD, we have not yet received any indication from industry that they will pursue MHD R&D on their own. No cost sharing proposal has been received in the past year in connection with the Department's technology base efforts. However, we believe the private sector is in a position to continue to develop MHD technology if they really want to, based on the Federal Government's efforts to date. It is anticipated that the large amount of equipment and facilities having significant value and owned by the government can be made available to private industry in a manner that will allow industry to continue the development of the technology consistent with their interest and funding availabilities.

PROPOSED MHD PHASE-OUT

Question: If the reason for the proposed MHD phase-out is the high cost of the next phase of MHD development, something we just can't afford at this time, is DOE leaving itself open for the possibility of MHD funding resurfacing when the economic climate improves, or has DOE given up entirely on the technical feasibility and energy potential of this technology?

Answer: DOE has not given up on the technical feasibility and energy potential of MHD and we will continue to look at the development of MHD technology. However, MHD is extremely costly and in light of the severe budgetary constraints the Department has reassessed its priorities for fossil energy technologies and determined that other technologies could contribute more generic information across a broader range of energy markets at lower investment requirements, and with significantly more cost sharing. In addition, other fossil energy technologies offer faster paybacks with smaller investment requirements and promise to contribute, in a timely fashion, to dealing with the forecasted electric utility shortfalls in the 1990s.

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Congress of the United States
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Washington, DC 20515

March 6, 1985

Mr. William A. Vaughan
Assistant Secretary
For Fossil Energy
U.S. Department Of Energy
Washington, DC 20585

Dear Mr. Vaughan:

Following-up on the hearing before the Energy Development and Applications Subcommittee yesterday, I had two additional questions for your response.

(1) As you know, Argonne National Laboratory conducts many research activities which are funded under the Fossil Energy Program. For instance, MHD-related R&D is performed and efforts are carried out in the coal gasification field. Consequently, I am very concerned over the impact a 30% funding reduction in fossil energy R&D will have on this valuable lab.

Could you please provide me with detailed information on what Argonne activities would be affected by the Department's budget request, and to what extent? Please include funding cutbacks by program area and the expected manpower reductions this would entail.

(2) With respect to the Department's overall budget request for FY 1986, the Committee recognizes the urgency of reducing federal spending, but, do you believe DOE has adequately balanced, or distributed, these demands for increased austerity? Do the short-term savings of drastically reducing some of the fossil energy programs in FY 1986 outweigh the potential costs associated with terminating these programs prematurely?

What indications have you received from the cost-sharing industries in the R&D programs which are proposed for such enormous cuts that they will continue their efforts in the absence of federal support?

Over the last ten years, over $300 million in federal funding has been provided to establish the technical feasibility of phosphoric acid fuel cells. This is a substantial investment, one we don't want to see wasted. Are you confident the industries involved in this effort to date will continue to advance the technology on their own?

DOE's justification for terminating the MHD program is quite confusing. As stated in the budget, "the MHD program is believed to be a costly, long-range, high-risk effort." Yet, the Reagan Administration philosophy for the last four years has been to specifically fund only long-term, high-risk R&D which the private sector cannot be expected to perform on their own. How do you explain this inconsistency in policy?

If the reason for the proposed MHD phase-out is the high cost of the next phase of MHD development, something we just can't afford at this time, is DOE leaving itself open for the possibility of MHD funding resurfacing when the economic climate improves, or has DOE given up entirely on the technical feasibility and energy potential of this technology?

Thank you for your cooperation. I would appreciate your responding directly to me on these questions.

Very truly yours,

Harris W Fawell

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HWF/sr